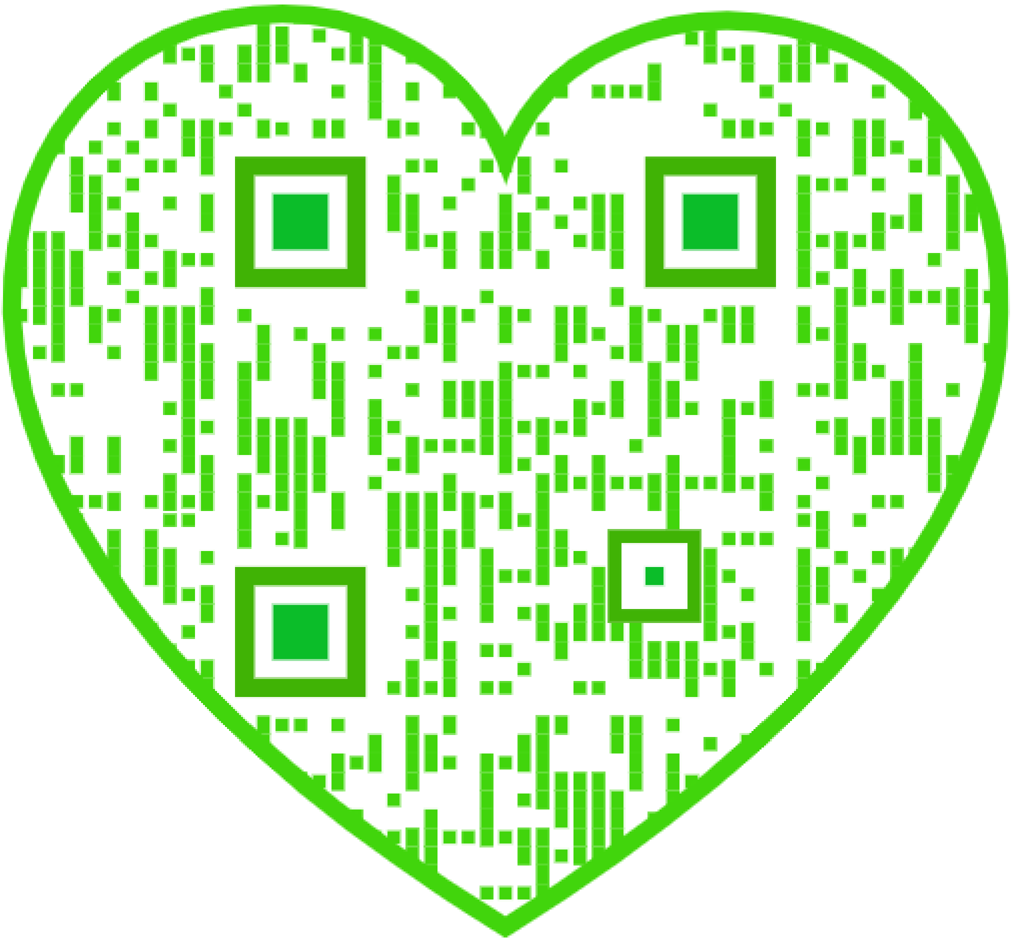

DEPARTMENT OF COMMERCE AND LABOR
COAST AND GEODETIC SURVEY
O. H. TITTMANN
SUPERINTENDENT

GEODESY

THE EFFECT OF TOPOGRAPHY AND ISOSTATIC COMPENSATION UPON THE INTENSITY OF GRAVITY

BY

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EFFECT OF TOPOGRAPHY AND ISOSTATIC COMPENSATION UPON THE INTENSITY OF GRAVITY.

BY

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AND

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GENERAL STATEMENT.

In the United States the assumption of isostasy in a definite and reasonable form has been introduced into the computations of the figure and size of the earth from the observed deflections of the vertical. These computations have shown that the assumption of isostasy is substantially correct. They have shown that a close approach to perfect isostatic compensation exists under the United States and adjacent areas. This is important to geology and geophysics. They have also shown that the proper recognition of isostasy in making computations of the figure and size of the earth from observed deflections of the vertical has about doubled the accuracy of such computations by reducing errors of both the accidental and the systematic classes in such work. This increase in accuracy is important to geodesy. These computations and the investigations of which they form a part have been published in full.†

As soon as it was evident that the proper recognition of isostasy in connection with computations of the figure and size of the earth from observed deflections of the vertical would produce a great increase in accuracy, it appeared to be very probable that a similar recognition of isostasy in connection with computations of the shape of the earth from observations of the intensity of gravity would produce a similar increase of accuracy. Logically the next step to be taken was therefore to introduce such a definite recognition of isostasy into gravity computations. Moreover, it appeared that if this step were taken it would furnish a proof of the existence of isostasy independent of the proof furnished by observed deflections of the vertical, and would therefore be of great value in supplementing the deflection investigations and in testing the conclusions drawn from them. In other words, the effects of isostasy upon the direction of gravity at various stations on the earth's surface having been studied, it then appeared to be almost equally important to investigate the effects of isostasy upon the intensity of gravity.

It was evident from the beginning that to properly take into account the possible existence of isostasy in connection with computations of the intensity of gravity a rather extensive revision of formulæ and methods of computation would be necessary, and that the computations must be thorough and must involve a considerable number of gravity stations if the results were to be convincing. Thus it was realized that the problem was both a large and a difficult one. Partly for this reason, Mr. Hayford, as inspector of geodetic work, recommended frequently from 1900 to 1908 that the Coast and Geodetic Survey confine its energy in geodetic observations and investigations mainly to deflections of the vertical until that part of the field of investigation had been well covered and reasonably safe conclusions reached, and that then, and not till then, should much energy be expended in gravity observations and the corresponding investigations. This policy was adopted and adhered to.

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† The Figure of the Earth and Isostasy from Measurements in the United States, by John F. Hayford, published in 1909 by the Coast and Geodetic Survey, and Supplementary Investigation in 1909 of the Figure of the Earth and Isostasy, by John F. Hayford, published in 1910 by the Coast and Geodetic Survey. Each of these is a separate publication not included in the annual reports of the survey. They may be obtained by interested parties on application to the Superintendent of the Coast and Geodetic Survey, Washington, D. C.

In the summer of 1908 Mr. Hayford began an extensive study of the theoretical side of the investigation, the revision of formulæ and of methods of computation.

Early in 1909 a long, continuous series of gravity observations with the half-second pendulum apparatus at various stations in the United States was commenced. This series is still in progress. In this publication there are used 89 stations, including those of this series which are available at this time.

In January, 1909, Mr. Bowie became closely associated with Mr. Hayford at the Coast and Geodetic Survey office and was brought into close touch with the investigation set forth in this publication. In October, 1909, he assumed his present position, and has since that time been in charge of the gravity observations and computations of gravity made in the Coast and Geodetic Survey, of which many are utilized in this publication. In certain lines he has extended the investigation beyond its former limits. In the preparation of this publication the two authors have cooperated. They are jointly responsible for the opinions expressed and the statement of conclusions reached.

Miss Sarah Beall, computer, efficiently supervised much of the computing in connection with this investigation, and especially the computation of the reduction tables, the most difficult part of the work. To her and to the various members of the computing division who assisted, the credit is largely due for the unusual rapidity and success of the computations.

In September, 1909, Mr. Hayford presented to the International Geodetic Association at London a paper bearing the same title as the present publication. It has been printed as pages 365–389 of Volume I of the Report of the Sixteenth General Conference of the International Geodetic Association, held at London and Cambridge in September, 1909.

The present investigation is in many respects a counterpart of the previous investigations based on deflections of the vertical, to which reference has already been made. It supplements those investigations, and therefore the three should be studied together to obtain their full force.

The computations of the present investigation have been based upon certain assumptions as to the existence of the condition called isostasy which are substantially identical with the assumptions in the previous investigations involving deflections of the vertical. It is important to the reader to understand clearly the meaning of the word isostasy and of certain related phrases, as otherwise he may fail to understand, or may misunderstand, many statements in this publication. These definitions are given below in substantially the same words as were used in connection with the previous investigations.

ISOSTASY DEFINED.

If the earth were composed of homogeneous material, its figure of equilibrium, under the influence of gravity and its own rotation, would be an ellipsoid of revolution.

The earth is composed of heterogeneous material which varies considerably in density. If this heterogeneous material were so arranged that its density at any point depended simply upon the depth of that point below the surface, or, more accurately, if all the material lying at each equipotential surface (rotation considered) was of one density, a state of equilibrium would exist, and there would be no tendency toward a rearrangement of masses. The figure of the earth in this case would be a very close approximation to an ellipsoid of revolution.

If the heterogeneous material composing the earth were not arranged in this manner at the outset, the stresses produced by gravity would tend to bring about such an arrangement; but as the material is not a perfect fluid, since it possesses considerable viscosity, at least near the surface, the rearrangement will be imperfect. In the partial rearrangement some stresses will still remain, different portions of the same horizontal stratum may have somewhat different densities, and the actual surface of the earth will be a slight departure from the ellipsoid of revolution in the sense that above each region of deficient density there will be a bulge or bump on the ellipsoid, and above each region of excessive density there will be a hollow, relatively speaking. The bumps on this supposed earth will be the mountains, the plateaus, the continents; and the hollows will be the oceans. The excess of material represented by that portion of the continent which is above sea level will be compensated for by a defect of density in the underlying material. The continents will be floated, so to speak, because they are composed of relatively light material; and, similarly, the floor of the ocean will, on this supposed earth, be depressed because it is composed of unusually dense material. This particular condition of approximate equilibrium has been given the name "isostasy."

The adjustment of the material toward this condition, which is produced in nature by the stresses due to gravity, may be called the "isostatic adjustment."

The compensation of the excess of matter at the surface (continents) by the defect of density below, and of surface defect of matter (oceans) by excess of density below, may be called the "isostatic compensation."

Let the depth below sea level within which the isostatic compensation is complete be called the "depth of compensation." At and below this depth the condition as to stress of any element of mass is isostatic; that is, any element of mass is subject to equal pressures from all directions as if it were a portion of a perfect fluid. Above this depth, on the other hand, each element of mass is subject in general to different pressures in different directions—to stresses which tend to distort it and to move it.

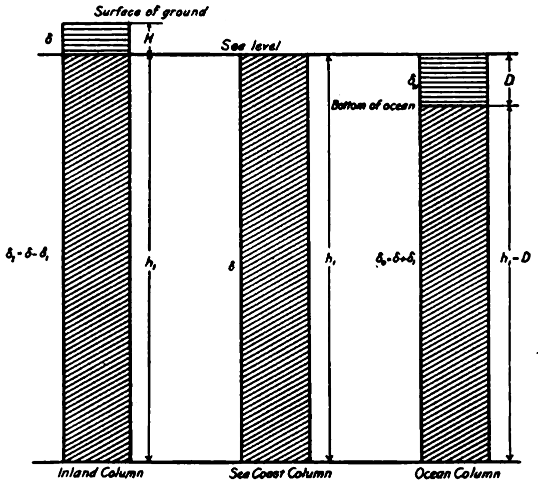

Illustration No. 1.—Three unit columns showing ideal depth of isostatic compensation.

Consider the relations of the masses, densities, and volumes, above the depth of compensation, fixed by the preceding definition. The mass in any prismatic column which has for its base a unit area of the horizontal surface which lies at the depth of compensation, for its edges vertical lines (lines of gravity) and for its upper limit the actual irregular surface of the earth (or the sea surface if the area in question is beneath the ocean) is the same as the mass in any other similar prismatic column having any other unit area of the same surface for its base.* Illustration No. 1 represents three such unit columns. Let the depth of compensation be called h_1 and the mean surface density of the solid portion of the earth be called δ. Then the mass of material in a column of unit area at the seacoast is δh_1 † (density times volume).

Let the elevation above sea level of the irregular surface of the earth over the unit area of an inland column be called H. Then the mass of material in the inland column above sea level is δH. Also, let the density of that portion of the inland column between sea level and the depth of compensation be called δ_I. Then the mass of material in the column is expressed by the equation

$$\text{Mass in any land unit column} = \delta H + \delta_I h_1 \qquad (1)$$

By definition, at the depth of isostasy, any element of mass is subject to equal pressures from all directions as if it were a portion of a perfect fluid. In order that this may be true, the vertical pressures due to gravity on the various units of area at that depth must all be the same, and therefore masses of the various unit columns must all be the same. Therefore the mass in a land unit column must be equal to the mass in a seacoast column, or

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* It would be more accurate to use the words "inverted truncated pyramid" instead of "prismatic column." The latter expression has been selected because it is sufficiently exact for the purpose and corresponds to the allowable approximations actually made in the mathematical part of the investigation.

† For the purpose of this demonstration it is assumed that the average density of the earth's crust below the seacoast between sea level and the depth of compensation is equal to the average density of the solid portion of the earth's surface (2.67). This assumption ignores the probability that within a depth as great as 114 kilometers (the assumed depth of compensation) there is probably a slight increase in density with increase of depth, due to increased pressure, the density being some unknown function of the depth. This neglect also appears in various other places in this publication. It is shown later, under the heading "Discussion of errors," that this neglect introduces no appreciable errors into the computation. It is justified, therefore, as a means of avoiding unnecessarily long and complicated statements.

$$\delta H + \delta_l h_1 = \delta h_1 \tag{1a}$$

From equation (1*a*) it follows that

$$\delta_l = \frac{\delta(h_1 - H)}{h_1} \tag{2}$$

The difference called δ_1 between δ and δ_l is expressed by the equation

$$\delta_1 = \delta - \frac{\delta(h_1 - H)}{h_1} \tag{2a}$$

$$= \delta \frac{H}{h_1} \tag{3}$$

This difference between the normal density at the surface of the land and also throughout a column at the seacoast on the one hand, and the density of an inland column below sea level on the other hand, is the average compensating defect of density, and this difference multiplied by the depth of compensation is the compensating defect of mass, $\delta_1 h_1$.

The total mass in the inland column may also be expressed by the equation (see illustration No. 1),

$$\text{Mass in any land unit column} = \delta H + \delta h_1 - \delta_1 h_1 \tag{4}$$

As the mass in each unit column is the same, namely δh_1, it is obvious from equation (4) that

$$\delta H = \delta_1 h_1 \tag{4a}$$

This equation is a statement in mathematical symbols that in each unit column the compensating defects of mass below sea level must be exactly equal to the mass above sea level which is considered to be the surface excess.

Equation (3) indicates that the compensating defect of density is proportional to the elevation of the surface above the sea level as δ and h_1 are assumed to be constant.

In an ocean unit column the top of the solid portion happens to be below sea level, being a part of the bottom of the ocean. In the ocean column let the depth of the water be called D and the density of the sea water δ_w. Then the depth of the solid portion of the column will be $h_1 - D$. Let the density of this solid portion be called δ_o. Then the mass of material in this unit column will be expressed by the equation

$$\text{Mass in any ocean unit column} = \delta_w D + \delta_o (h_1 - D) \tag{4b}$$

By definition, this mass must equal the mass of the unit column at the seacoast, hence

$$\delta_w D + \delta_o (h_1 - D) = \delta h_1 \tag{4c}$$

From equation (4*c*) it follows that

$$\delta_o = \frac{\delta h_1 - \delta_w D}{h_1 - D} \tag{4d}$$

The difference δ_1 between the density of the solid portion of the ocean column δ_o and the normal density δ is expressed by the equation

$$\delta_1 = \frac{\delta h_1 - \delta_w D}{h_1 - D} - \delta \tag{4e}$$

$$= \frac{(\delta - \delta_w) D}{h_1 - D} \tag{4f}$$

The total mass in any ocean unit column may also be expressed by the equation (see illustration No. 1),

$$\text{Mass in any ocean unit column} = \delta_w D + (\delta + \delta_1)(h_1 - D) \tag{5}$$

As the mass in each unit column is the same, namely δh_1, it follows from equation (5) that

$$D(\delta-\delta_w)=\delta_1(h_1-D) \qquad (5a)$$

That is, in the solid portion of each ocean unit column the compensating excess of mass must be exactly equal to the defect of mass in the water portion of the column.

Equation (4*f*) indicates that the compensating excess of density is nearly proportional to the depth of water, as δ and δ_w are assumed to be constant and (h_1-D) is approximately constant.

In this publication the mean surface density of the solid portion of the earth, δ, is assumed to be 2.67. The density of sea water, δ_w, is 1.027. With these values $\delta-\delta_w=0.615\delta$. Hence, for oceanic unit columns, equation (5*a*) becomes

$$(\delta-\delta_w)D=0.615\delta D=\delta_1(h_1-D) \qquad (5b)$$

and equation (4*f*) becomes

$$\delta_1=\delta\frac{0.615D}{h_1-D} \qquad (6)$$

Note that equation (6) differs from equation (3) only by containing the factor 0.615; in having D, a depth, in the place of H, an elevation; and in having (h_1-D) as a denominator instead of h_1.

As a concrete illustration, consider three unit columns such as are indicated in illustration No. 1, one beneath a mountain summit at an elevation of 3 kilometers, one underlying an area which is at sea level, a portion of the seashore for example, and the third under the ocean at a point where it is 5 kilometers deep. Let the depth of compensation be assumed to be 114 kilometers below sea level, and the mean surface density $\delta=2.67$. In the first column the ratio H to h_1 being $\frac{3}{114}$, according to equation (3) the defect of density, δ_1, is $\frac{3}{114}$ of 2.67 or 0.07, and the density of the material below sea level is $2.67-0.07=2.60$. In the second column the density of the material is 2.67. In the third column the compensating excess of density of the material underlying the ocean is, by equation (6), $\delta\frac{(0.615)(5)}{114-5}=\delta\frac{3}{109}=0.07$ and the density of the material is therefore $2.67+0.07=2.74$.

Under such a mountain, therefore, if isostasy exists as defined by the stated assumptions, the average density is about 3 per cent less than under the seacoast, and on the other hand, under a portion of the ocean 5 kilometers deep the average density is about 3 per cent greater than under the seacoast, down to the depth of compensation in each case.

As a rough approximation it may be stated, on the basis of the preceding paragraph, that beneath areas which lie above sea level the density is defective by about 1 per cent for each kilometer of elevation of the surface. Since much of the land portion of the earth's surface is at an elevation of less than 1 kilometer and very little of it above the elevation 3 kilometers, the compensating defects of density beneath most land areas are less than 1 per cent of the mean density and exceed 3 per cent only under a few small areas on very high mountains. Similarly, the compensating excesses of density under ocean areas seldom exceed 3 per cent as the depths exceed 5 kilometers (16 000 feet or 2700 fathoms) in but a small portion of the ocean.

If the condition of equal pressures, that is of equal superimposed masses, is fully satisfied at a given depth, the compensation is said to be complete at that depth. If there is a variation from equality of superimposed masses, the differences may be taken as a measure of the degree of incompleteness of the compensation.

In the above definitions it has been tacitly assumed that g, the intensity of gravity, is everywhere the same at a given depth. Equal superincumbent masses would produce equal pressures only in case the intensity of gravity is the same in the two cases. The intensity of gravity varies with change of latitude and is subject also to anomalous variations which are to some extent associated with the relation to continents and oceanic areas. But even the extreme variations in the intensity of gravity are small in comparison with the variations in density postulated. The extreme variation of the intensity of gravity at sea level on each side of its mean value is only 1 part in 400. Even this small range of variation does not occur except between points which are many thousands of kilometers apart. As will be shown later, the postulated variations in mean densities are about 1 part in 30 on each side of an average value. Hence, it is not advisable to complicate the conception of isostasy and introduce long circumlocutions into its definition in order to introduce the refinement of considering the variations in the intensity of gravity.

The variation of the intensity of gravity with change of depth below the surface need not be considered, as its effect in the various columns of material considered will be substantially the same.

The idea implied in this definition of the phrase "depth of compensation," that the isostatic compensation is complete within some depth much less than the radius of the earth, is not ordinarily expressed in the literature of the subject,* but it is an idea which it is difficult to avoid if the subject is studied carefully from any point of view.

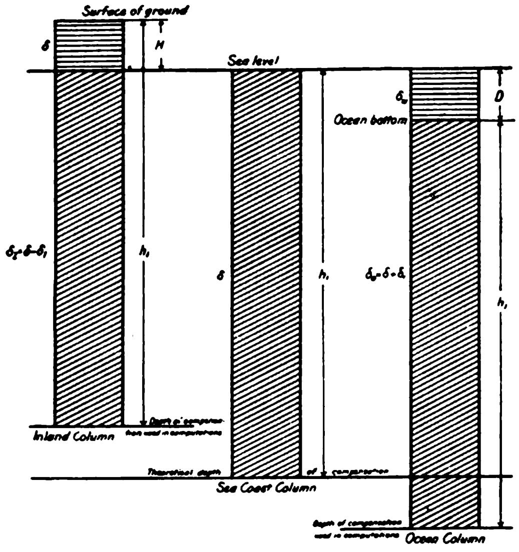
Surface of ground
δ
H
Sea level
δ_w
D
Ocean bottom
$\delta_2 = \delta - \delta_1$
h_1
δ
h_1
$\delta_4 = \delta + \delta_3$
h_1
Depth of compensation used in computations
Inland Column
Theoretical depth of compensation
Sea Coast Column
Depth of compensation used in computations
Ocean Column

ILLUSTRATION No. 2.—Three unit columns showing approximate depth of isostatic compensation as used in computations.

ASSUMPTIONS AS TO ISOSTASY.

In the computations of the investigation here published the depth of compensation is assumed to be 113.7 kilometers under every separate portion of the earth's surface.

This is substantially the value given in The Figure of the Earth and Isostasy, page 175. It was the best value available at the time the computation of the gravity reduction tables published herein was commenced. A better value, 122 kilometers, became available while these computations were in progress, but too late to be used. (See Supplementary Investigation in 1909 of The Figure of the Earth, p. 77.)

The mean surface density of the earth—that is, the mean density of the solid portion of the earth for the first few miles below the surface—is assumed in this investigation to be 2.67.† The phrase "of the solid portion of the earth" is inserted in the preceding sentence to indicate that the ocean, with a density of only 1.027, is excluded from this mean.

The computations concerned in this investigation were actually made on the assumption indicated in illustration No. 2 instead of those indicated in illustration No. 1 and used on pages 7–9. This slight change was made to simplify and facilitate computations and is justified by the fact that the errors so introduced are negligible, as shown later under the heading "Discussion of errors." In illustration No. 1 and in the corresponding text, the compensation is assumed to extend everywhere to a depth of 113.7 kilometers below sea level. In illustration No. 2 and in the actual computations, the compensation is assumed to extend everywhere to a depth of 113.7 kilometers measured downward from the solid surface of the earth—that is, from the land surface in land areas (above sea level) and from the ocean bottom in oceanic areas (below sea level). For land areas, in computing the direct effect of the topography, the portion above sea level was assumed to have the density δ as indicated in illustration No. 2, but in computing the effect of the isostatic compensation the density was assumed to be $\delta - \delta_1$

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* See, however, a reference to Pratt's Hypothesis in Helmert's Höhere Geodäsie, II Theil, p. 367.

† For the data and considerations upon which this value is based, see The Solar Parallax and its Related Constants, by William Harkness, Washington, Government Printing Office, 1891, pp. 91-92; see also The Figure of the Earth and Isostasy from Measurements in the United States, p. 128.

above sea level as well as below, δ_1 being computed from formula (3). The seacoast column is the same in the two illustrations. Upon the assumption indicated in illustration No. 2 and used in actual computations for oceanic compartments, formula (6) becomes

$$\delta_1 = \delta \frac{0.615\ D}{h_1} \tag{6a}$$

In the computations of this investigation the compensation under each separate portion of the earth's surface is assumed to be uniformly distributed with respect to depth from the surface down to the depth of compensation, 113.7 kilometers. In other words, the compensating defect or excess of density under a given area is assumed to be, at all depths less than the depth of compensation, exactly equal to the δ_1 of equations (3) and (6), which was defined as being the average defect (or excess) of density.

Elsewhere * it has been assumed temporarily for investigation purposes that the compensating defect (or excess) of density varies with respect to depth, being for example greatest near the surface and diminishing uniformly to zero at the depth of compensation, its average value being δ_1.

In the principal computations of this investigation the isostatic compensation is assumed to be complete under every separate portion of the earth's surface, however small the area considered. That is, equations (3) and (6) are assumed to be true for every separate unit of area even though a very small unit be chosen, as for example, 1 square foot.

The authors do not believe that any one of these assumptions upon which the computations are based is absolutely accurate. The mean surface density is probably not exactly 2.67 and the actual surface density in any given area probably does not agree exactly with the mean. The depth of compensation is probably not exactly 113.7 kilometers, and it possibly is somewhat different under different portions of the earth's surface. The compensation is probably not distributed uniformly with respect to depth. It is especially improbable that the compensation is complete under each separate small area, under each hill, each narrow valley, and each little depression in the sea bottom. It is exceedingly improbable, for example, that as each ton of material is eroded from a land area, carried out of a river mouth, and deposited on the ocean bottom, that corresponding changes of isostatic compensation occur at the same time under the eroded area and under the area of deposition at just such a rate as to keep the compensation complete under each.

The authors believe that the assumptions on which the computations are based are a close approximation to the truth. They believe also that the quickest and most effective way to ascertain the facts as to the distribution of density beneath the surface of the earth is to make the assumptions stated, to base upon them careful computations for many observation stations scattered widely over the earth's surface, and then to compare the computed values with the observed values of the intensity of gravity in order to ascertain how much and in what manner the facts differ from the assumptions.

In this investigation, accordingly, the intensity of gravity at many observation stations has been computed on the assumptions stated. These computed values have been compared with the observed values at these stations. The differences between the observed and the computed values, the residuals, are due to two classes of errors. In the first class are errors in the observations and in the computations. In the second class are errors in the assumptions. The average and maximum magnitudes of the errors of the first class are fairly well known. The magnitude and character of the residuals which may be produced by them are fairly well known. It is shown in this publication that the residuals, differences between observed and computed values of the intensity of gravity, are larger than may be accounted for by the first class of errors. Therefore it is certain that the second class of errors are of appreciable size. In other words, it is certain that the assumptions are appreciably in error. But, as the residuals are but little larger than may be accounted for by the first class of errors, it is certain that the assumptions are nearly correct.

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* The Figure of the Earth and Isostasy from Measurements in the United States, pp. 156–163.

The residuals contain evidence not only as to the extent but also as to the manner in which assumptions depart from the truth. To read and interpret this evidence precisely is exceedingly difficult because of the fact that the residuals are small. If the residuals were large, it would be clear that the assumptions were far from the truth, and it would be easy to see in which direction the truth lay. In the actual case it is difficult to ascertain in what way the assumptions should be changed to make them a closer approximation to the whole truth, while still remaining a statement of general laws applicable to the whole United States.

FORMULÆ.

It was desired to compute the intensity of gravity at any selected station on the earth upon the assumptions as to isostasy which have been stated. It was necessary to select the formulæ and methods of computation.

The computations may be most conveniently made in two parts.

First, the intensity of gravity may be computed on an ideal earth having the same size and shape as the ellipsoid of revolution which most nearly coincides with the sea-level surface of the real earth, and having no topography and no variations in density at any given depth below the surface. To convert the real earth into this ideal earth all material on the real earth above sea level must be removed, the water of the ocean must be replaced by material of density equal to the mean surface density of the real earth, and all variations in density at any given depth in the real earth must then be removed by taking out or injecting enough material in each part to make the density conform accurately to the mean density in the real earth at that depth. In this ideal earth the density will increase with increase of depth in the same manner as it does upon an average in the real earth, but in the ideal earth all masses lying at the same depth will have the same density, whereas in the real earth such masses have densities which are known to differ slightly from each other.

This computation was made by using Helmert's formula of 1901,* namely,

$$\dagger\,\gamma_0 = 978.046(1+0.005\,302\sin^2\phi-0.000\,007\sin^2 2\phi) \tag{7}$$

The symbol γ_0 stands for the required value of gravity at a station on the ideal earth above described in the latitude ϕ. On such an ideal earth the value of gravity at the surface would be a function of the latitude only, as expressed by this formula. The numerical value of γ_0 computed from formula (7) is both the acceleration of gravity in centimeters and the attraction of gravity in dynes on a unit mass (1 gram) at the station expressed in the centimeter-gram-second system.

The form of this formula is fixed by theory. The three constants which it contains, namely, 978.046, 0.005 302, and 0.000 007, were computed from a large number of observations of gravity at stations scattered widely over the earth's surface. New and better values of these constants may be obtained by further research and the use of more observations, but at the beginning of this investigation the formula as written was believed to be the best representation available

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* Der normale Theil der Schwerkraft im Meeresniveau, von F. R. Helmert, S. 328–336, Sitzungsberichte / der Königlich Preussischen / Akademie der Wissenschaften / zu Berlin, / Jahrgang 1901 / Erster Halbband, Januar bis Juni. See also Bericht über die relativen Messungen der Schwerekraft mit Pendelapparaten für den Zeitraum von 1900 bis 1903, unter Mitwirkung von F. R. Helmert erstattet von E. Borrass, S. 133–136, Verhandlungen / der vom 4 bis 13 August 1903 in Kopenhagen abgehaltenen / Vierzehnten Allgemeinen Conferenz der / Internationalen Erdmessung / Redigirt vom ständigen Secretär H. G. van de Sande Bakhuyzen. / II. Theil: Spezialberichte. See also The Figure of the Earth and Isostasy from Measurements in the United States, p. 172, for some comments upon this formula.

† After the manuscript of this publication was completed, a letter addressed to the Superintendent, of which the following is a translation, was received from Dr. Helmert:

POTSDAM, *October 31, 1911.*

Mr. Bowie sent to me a small brochure for which I offer my best thanks to the sender and to you. Permit me to make a remark in regard to my formula.

In 1901 I did indeed give:

$$\gamma_0 = 978.046\ (1+0.005302\sin^2\phi-0.000007\sin^2 2\,\phi)$$

This formula is based on the value of g in the Vienna system (Sterneck).

The American values of g are, however, referred to Potsdam. The constant 978.046 must, therefore, be modified by the application of −0.016 by which correction it is referred to Potsdam, as I have several times stated in my reports.

I therefore request that in your investigations in North America you will use the value

$$\gamma_0 = 978.030\ (1+0.005302\sin^2\phi-0.000007\sin^2 2\,\phi)$$

as being my improved formula.

I know that your scientists think that the value 978.038 is more suitable for the United States. That value, of course, may be used. I only wanted to emphasize that, in so far as my work is concerned, the value of g in the United States is not 978.046, but 978.030.

It is clear that the values of gravity in the United States, used in this publication, are based upon Potsdam, as shown on p. 73, and that, therefore, the position taken by Dr. Helmert in this letter is correct. The only manner in which this change ultimately affects the conclusions reached in this publication is shown on p. 75.

of gravity at sea level on the ideal earth described in the preceding paragraph. During the progress of this investigation a small correction to the constant 978.046 was derived, as shown later in this publication. The formula, with this small correction applied, is believed by the authors to be the best available at present for the purpose for which it is intended.

The Helmert formula of 1901 corresponds to a value of 298.3 ± 0.7 for the reciprocal of the flattening of the earth. This is in fair agreement with the best value now available for this quantity as derived from observed deflections in the United States, namely, 297.0 ± 0.5.[*]

The stations at which observations of gravity were made are situated on the real earth, not the ideal earth, and are in general above sea level, not at sea level. The second portion of the computation of the intensity of gravity at any observation station must therefore take account of the topography which exists upon the real earth, take account so far as is possible of the variations in density beneath the surface of the real earth, and take account of the effect of the elevation of the observation station above sea level.

The correction for elevation was computed by the formula

$$-0.000\,308\,6\ H$$

in which H is the elevation of the station above sea level in meters. This correction of the attraction upon a unit mass (1 gram) at the station is in dynes and reduces from sea level to the actual station. It takes account of the increased distance of the station from the attracting mass, the earth, as if the station were in the air at the stated elevation and there were no topography on the earth. This is an old formula and needs no comment other than that it has been adopted in this simple form by Dr. Helmert as being sufficiently accurate.[†]

The real difficulty of the investigation was encountered when an attempt was made to compute the effect, upon the attraction at a given station, of the topography which exists upon the earth and of the isostatic compensation of that topography which is assumed to exist beneath the surface of the earth. For this purpose new formulæ and new methods of computation were found to be necessary.

It was desired to compute the effect upon the attraction at each station of all the topography of the world and of the isostatic compensation of that topography. It was desired to do this with sufficient accuracy to insure that all constant errors in the computed effects would certainly be less than 1 part in 200 and all accidental errors in the separate parts of the computation less than .0002 dyne. This, it was believed, would insure that the computed total correction for any station would ordinarily be in error in so far as the computation alone is concerned by less than 0.003 dyne. In order to make this computation with the specified degree of accuracy with a minimum expenditure of time and energy the formulæ and methods of computation about to be given were selected and used. This publication contains full information as to the degree of success with which the computations were made, both as to accuracy and rapidity. This degree of success is the proper measure of the excellence of the formulæ and methods of computation selected.

The attraction of any elementary mass, dm, acting upon a mass of 1 gram at the station of observation is, in dynes,

$$\frac{k\,dm}{D^2} \tag{8}$$

in which k is the gravitation constant and D is the distance from the station to the elementary mass. In order to get the result in dynes all quantities in this formula must be expressed in the centimeter-gram-second system.

The general expression for Newton's law of gravitation is

$$F = k\frac{m_1 m_2}{D^2} \tag{8a}$$

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[*] See Supplementary Investigation in 1909 of the Figure of the Earth and Isostasy, pp. 60, 77.

[†] See p. 651 of "Über die Reduction der auf der physichen Erdoberfläche beobachteten Schwerebeschleunigungen auf ein gemeinsames Niveau Von F. R. Helmert in Sitzungsberichte der Königlich Preussischen Akademie der Wissenschaften 1903 Erster Halbband.

in which m_1 and m_2 are two masses each of dimensions infinitesimal in comparison with the distance D between them and F is the attraction between the two masses. Newton's law of gravitation is frequently expressed merely in the form of a proportion, F being stated to be proportional to $\frac{m_1 m_2}{D^2}$. The gravitation constant, k in formula (8a), is the factor by which the product of two masses divided by the square of their distance asunder must be multiplied in order to express the force exerted by those masses on one another. The gravitation constant is not a mere numeral. Its dimensions are shown by the exponents in $(L^{+3} M^{-1} T^{-2})$ if L, M, T denote the units of length, mass, and time, respectively. That is, the gravitation constant is the cube of a distance divided by the product of a mass and the square of a time.

Formula (8) is merely the special case of formula (8a) which is pertinent to the problem in hand.

The value adopted in this investigation for k in the centimeter-gram-second system is 6673 (10^{-11}). The basis of this adopted value is as follows, as stated by Dr. R. S. Woodward:*

In spite of the superb experimental investigations made particularly during the past quarter of a century by Cornu and Baille (Comptes rendus, LXXVI, 1873), Poynting (The Mean Density of the Earth, by J. H. Poynting, London, Charles Griffin & Co., 1894), Boys (Philosophical Transactions, No. 186, 1895), Richarz and Krigar-Menzel (Sitzungsberichte, Berlin Academy, Band 2, 1896), and Braun (Denkschriften, Math. Natur. Classe, Vienna Academy, Bd. LXIV, 1897), it must be said that the gravitation constant is uncertain by some units in the fourth significant figure, and possibly even by one or two units in the third figure.

The results of the investigators mentioned for the gravitation constant are, in C. G. S. units, as follows, the first result having been computed from data given by MM. Cornu and Baille in the publication referred to:

Cornu and Baille (1873)	6668 (10^{-11})
Poynting (1894)	6698 (10^{-11})
Boys (1894)	6657 (10^{-11})
Richarz and Krigar-Menzel (1896)	6685 (10^{-11})
Braun (1897)	6658 (10^{-11})

Regarding these as of equal weight, their mean is 6673 (10^{-11}) with a probable error of ± 5 units in the fourth place, or 1/1330th part. This is of about the same order of precision as that deduced by Prof. Newcomb from astronomical data.

The uncertainty in the adopted value is, however, within allowable limits for the present investigation.

The vertical component at the observation station of the attraction expressed in formula (8) is, in dynes,

$$k dm \frac{\sin \beta}{D^2} \tag{9}$$

in which β is the angle of depression, below the horizon of the station, of the straight line from the station to the elementary mass.

This vertical component is all that is concerned in this investigation. The integral of all such vertical components at the station, corresponding to all the elementary masses which together constitute the earth, is the vertical force due to gravitation which acts on a mass of one gram placed at the station. This vertical force expressed in dynes is necessarily numerically equal to the acceleration (both being expressed in the centimeter-gram-second system) which would be produced by gravitation acting upon any mass at the station left free to fall. They are, of course, affected by the centrifugal force due to the earth's rotation, but this effect need not be considered in the discussion of these formulæ.

The term, gravity, is used in its generally accepted sense; that is, it is the resultant of the earth's gravitation and the centrifugal force due to the earth's rotation.

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* See p. 153 of an address entitled "The Century's Progress in Applied Mathematics," by R. S. Woodward, Bulletin of the American Mathematical Society, 2d Series, Vol. VI, No. 4, pp. 133-163. In this address and in another by the same author entitled "Measurement and Calculation," published in Science, new series, Vol. XV, No. 390, pp. 961-971, June 20, 1902, are given excellent statements of the nature of the gravitation constant and the importance of determining its value accurately.

In general it will be found that throughout this publication the attraction (expressed in dynes) is dealt with directly by preference rather than its numerical equivalent, the acceleration (expressed in centimeters and seconds). This preference is due to the belief that thereby circumlocutions are avoided and greater clearness secured in the conceptions.

If the station and the elementary mass, dm, are at the same elevation referred to sea level

$$\beta=\frac{\theta}{2}$$

and

$$D=2r\sin\frac{\theta}{2}$$

(see illustration No. 3), in which θ is the angle at the center of the earth subtended between the station and the elementary mass and r is the radius of the earth.

If absolute accuracy were desired it would be necessary to use for r the average radius of curvature, between the station and the mass considered, of the equipotential surface in which they both lie. This average radius depends upon the elevation above sea level and also, since the sea-level surface is an ellipsoid of revolution (not a sphere), it depends upon the latitude of the station and the azimuth of the line from the station to the mass under consideration. But with sufficient accuracy for this investigation r is assumed to be constant with the value 637 000 000 centimeters in this and similar formulæ. This is equivalent to assuming, in deriving these formulæ, that the station is on the surface of a spherical earth having the radius stated. Under the heading "Discussion of errors" it will be shown that this assumption is far within the allowable limits of approximation.

By substituting these values of β and D in (9) there is obtained as the formula for the vertical component of the attraction in dynes upon a unit mass at the station, due to an elementary mass which is at the same elevation as the station,

$$kdm\frac{\sin\frac{\theta}{2}}{4r^2\sin^2\frac{\theta}{2}}=kdm\ E \tag{10}$$

The single symbol E is used to represent that portion of the formula

$$\frac{\sin\frac{\theta}{2}}{4r^2\sin^2\frac{\theta}{2}}$$

which depends simply upon the direction and distance of the elementary mass from the station, because later it is most convenient to deal with E separately from k and dm. To divide both the numerator and denominator of (10) by $\sin\frac{\theta}{2}$ would simplify the expression, but by so doing the close analogy between (10) and the more complicated expressions (15) and (16) would become less obvious.

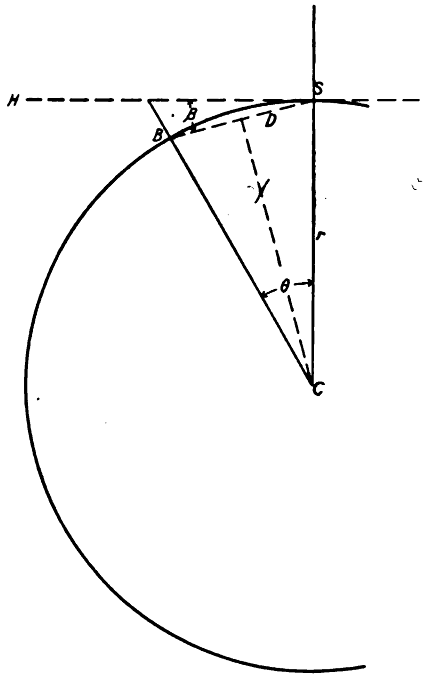

ILLUSTRATION No. 3.—Showing station and elementary mass at same elevation.

In each of the illustrations Nos. 3, 4, and 5, S represents the gravity station, and the circle represents the intersection of the level surface which lies at the elevation of the station with a plane defined by the station, the center of the earth (C), and the elementary mass considered.

B is the location of the elementary mass *dm*, β is the angle between the horizon of the station (*SH*) and the straight line from the station to *B*, and *D* is the distance from the station to *B*. In illustrations Nos. 4 and 5, D_1 is the distance from the station to a point *A* at the same elevation as the station and in the same vertical line as *B*, the location of the elementary mass.

Illustration No. 4 represents the case in which the elementary mass, *dm*, is higher than the station, the difference of elevation being *h*. In the triangle *SAB*, from the law of proportional sines,

$$\sin \beta_c = \frac{h \cos \frac{\theta}{2}}{D} \tag{11}$$

also, in this triangle, according to plane trigonometry,

$$D^2 = D_1^2 + h^2 + 2D_1 h \sin \frac{\theta}{2} \tag{12}$$

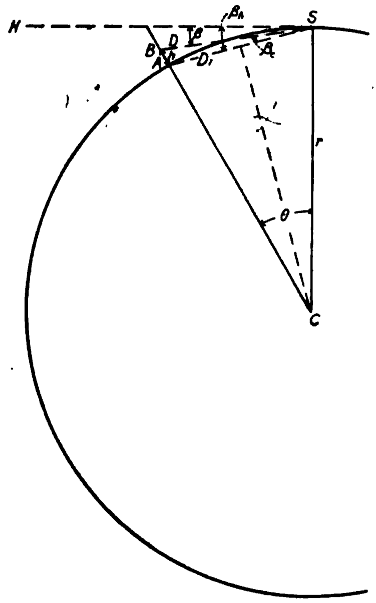

ILLUSTRATION No. 4.—Showing elementary mass at greater elevation than station.

From illustration No. 4 it appears that

$$\beta_h = \frac{\theta}{2} \tag{13}$$

and

$$\beta = \beta_h - \beta_c \tag{14}$$

By substituting from formulæ (11), (12), (13), and (14) in (9) there is obtained as the formula for the vertical component of the attraction in dynes upon a unit mass at the station, due to an elementary mass which is higher than the station,

$$kdm \frac{\sin \left(\frac{\theta}{2} - \sin^{-1} \frac{h \cos \frac{\theta}{2}}{\sqrt{D_1^2 + h^2 + 2D_1 h \sin \frac{\theta}{2}}} \right)}{D_1^2 + h^2 + 2D_1 h \sin \frac{\theta}{2}} = kdm\ E_1 \tag{15}$$

Here again a single symbol, E_1, is taken to represent that portion of the formula which depends simply upon the direction and distance of the elementary mass from the station.

Illustration No. 5 represents the case in which the elementary mass, *dm*, is lower than the station, the difference of elevation being *h*. By the same process as that used above it may be shown that the vertical component of the attraction in dynes upon a unit mass at the station, due to an elemontary mass which is lower than the station is

$$kdm \frac{\sin \left(\frac{\theta}{2} + \sin^{-1} \frac{h \cos \frac{\theta}{2}}{\sqrt{D_1^2 + h^2 - 2D_1 h \sin \frac{\theta}{2}}} \right)}{D_1^2 + h^2 - 2D_1 h \sin \frac{\theta}{2}} = kdm E_2 \tag{16}$$

in which E_2 is used to represent that part of the formula which depends simply upon the direction and distance of the elementary mass from the station.

It is important to note that the only approximation made in deriving formulæ (10), (15), and (16) is that to which attention has already been called, namely that the radius of curvature concerned at each station is 637 000 000 centimeters. In every other respect the derivation of the formulæ is exact regardless of the distance of the attracting mass from the observation station. The attracting mass may even be located at the antipodes of the station. These formulæ were used in connection with all attracting masses which are so far from the station that the curvature of the sea level surface must be taken into account in order to insure that the errors of computation of the effects are less than 1 part in 200.

For masses near the station, the well-known formula for the attraction of a mass having the form of a right cylinder upon a point outside the cylinder and lying in its axis produced was utilized.* This formula, in a convenient form for the present purpose, for the attraction in dynes upon a unit mass (1 gram) at the station, is

$$k2\pi\delta\{\sqrt{c^2+h^2}-\sqrt{c^2+(h+t)^2}+t\} \qquad (17)$$

in which k is the gravitation constant, δ is the density of the material, c is the radius of the cylinder, t is the length of an element of the cylinder, and h is the distance from the attracted point, the station, to the nearest end of the cylinder.

For a mass which has the form of a cylindrical shell, that is, the difference of two concentric right cylinders of the same length having different radii, c_1 and c_2 formula (17) becomes

$$k2\pi\delta\{\sqrt{c_2^2+h^2}-\sqrt{c_1^2+h^2}-\sqrt{c_2^2+(h+t)^2}+\sqrt{c_1^2+(h+t)^2}\} \qquad (18)$$

This is the attraction in dynes upon a unit mass (1 gram) at the station.

The formulæ (17) and (18) are exact if applied to cylinders and cylindrical shells.

The justification of the radical departure from past practice represented by formulæ (10), (15), and (16), and by the introduction of the gravitation constant into formulæ (17) and (18) is the success attained thereby in securing quick and accurate computations. The reader is therefore requested to suspend judgment until the remainder of this publication has been read and the degree of success has been compared with that obtained by the use of any other formulæ with which comparison is made.

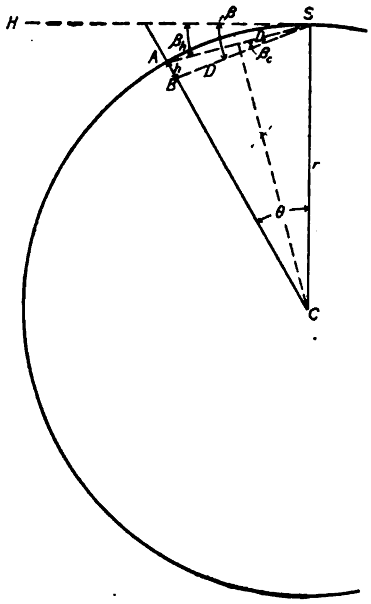

ILLUSTRATION No. 5.—Showing elementary mass at less elevation than station.

DIVISION OF THE SURFACE OF THE EARTH INTO ZONES AND COMPARTMENTS.

In order to apply formulæ (10), (15), (16), (17), and (18) to the computation of the effect of the topography and the isostatic compensation, the whole surface of the earth was divided into zones by circles, each having the station at its center, and each zone was divided into equal compartments by radial lines. The division adopted is shown in the following table. Illustrations Nos. 10*a* and 10*b*, page 48, show the shapes of certain compartments.

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* For two statements of this formula see A Treatise on Attractions, Laplace's Function and Figures of the Earth, by John H. Pratt, third edition, p. 46, and Traité de Mécanique Céleste, F. Tisserand, Tome II, pp. 71-72.

Designation of zone	Inner radius of zone	Outer radius of zone	Compartments
	Meters	*Meters*	
A	0	2	1
B	2	68	4
C	68	230	4
D	230	590	6
E	590	1 280	8
F	1 280	2 290	10
G	2 290	3 520	12
H	3 520	5 240	16
I	5 240	8 440	20
J	8 440	12 400	16
K	12 400	18 800	20
L	18 800	28 800	24
M	28 800	58 800	14
N	58 800	99 000	16
O	99 000	166 700	28
	° ′ ″	° ′ ″	
18	1 29 58	1 41 13	1
17	1 41 13	1 54 52	1
16	1 54 52	2 11 53	1
15	2 11 53	2 33 46	1
14	2 33 46	3 03 05	1
13	3 03 05	4 19 13	16
12	4 19 13	5 46 34	10
11	5 46 34	7 51 30	8
10	7 51 30	10 44	6
9	10 44	14 09	4
8	14 09	20 41	4
7	20 41	26 41	2
6	26 41	35 58	18
5	35 58	51 04	16
4	51 04	72 13	12
3	72 13	105 48	10
2	105 48	150 56	6
1	150 56	180	1

For the numbered zones it was found to be more convenient to use the radii of the zone in degrees and minutes of a great circle than in meters. The inner radius of zone 18 is the same as the outer radius of zone O, that is, on a sphere of the adopted size, radius 637 000 000 centimeters, 1° 29′ 58″ of a great circle (the inner radius of zone 18) has a length 166 700 meters (the outer radius of zone O). Zone A commences at the station, and zone 1 ends at the antipodes of the station. All the zones together cover the earth completely.

Zone A, with a single compartment, is a circle about the station with a radius of 2 meters. Similarly, zone 1, with a single compartment, is a circle about the antipodes of the station with a radius of 29° 04′ (3240 kilometers). Zones 18 to 14 each have a single compartment. All other zones have from 2 to 28 compartments each, the number of compartments being even in each case.

For each zone a special reduction table was prepared in the manner indicated hereafter under the heading, "Computation of reduction tables." This table for each zone gives the relation between the mean elevation of the surface of the ground in each compartment of that zone and the effect of topography and the isostatic compensation in that compartment upon the vertical component of the attraction at the station.

In making the arbitrary selection of radii of zones and of the number of compartments in each zone, it was necessary to consider the effect of the size and shape of the compartment; first, upon the time required to complete the computations; second, upon the accuracy of the computations in so far as it depends upon the accuracy of the estimates made by the computer of the mean elevation within each compartment; and, third, upon the accuracy of certain necessary assumptions in the computation.

The larger the compartments are made, the smaller will be the number of compartments, and therefore the smaller the number of estimates of mean elevation to be made, one for each compartment. But as the compartments are made larger, the time required for each estimate becomes greater. For with a large compartment it is necessary to estimate the mean elevation more closely to secure a given degree of accuracy than with a small compartment; to estimate to the nearest hundred feet, for example, instead of to the nearest thousand feet. Also, the larger the compartment the greater the total range of elevations within the compartment, and therefore the greater the time necessary to secure an estimate of the mean to a given degree of accuracy. Hence the adoption of compartments either too large or too small would have made the time required for the computation greater than would otherwise have been necessary.

There are 317 compartments in all, 199 in the 15 lettered zones near the station, and 118 in the 18 numbered zones, all of which are more than 166 kilometers from the station.

It is believed that the size and shape of each compartment has been so fixed that the error of computation for any compartment is ordinarily less than 0.0002 dyne, and is of the accidental class. The basis of this belief will be indicated in connection with the topic, "Discussion of errors." It is known that notable success has been attained in securing rapid computation.

With the experience now available, a better selection of radii of zones, and of numbers of compartments in each zone could be made. But such a new selection would make it necessary to recompute the reduction tables. It is not probable that the improvement would be sufficient to warrant this recomputation.

COMPUTATION OF REDUCTION TABLES FOR NEAR ZONES.

For zone A, comprising the surface of the earth in a circle around the station with a radius of 2 meters, the reduction table was computed by formula (17).

The effect of the topography in this zone, if the station is on land, is the effect of a cylinder of material having the density, δ, assumed to be the mean surface density of the earth, namely, 2.67, having a radius $c=200$ centimeters and a length, t, equal to the elevation of the station. In the formula $h=o$ for this case, as the station is at the end of the cylinder in question. The elevation of the surface of the ground in all parts of this small zone is assumed in the computation to be the same as the elevation of the station.

In the computations it was necessary, of course, to express all distances in centimeters to conform to the adopted value of k, which is expressed in the centimeter-gram-second system. (See p. 13.)

The attraction computed is evidently a vertical force, as the station lies in the axis of the cylinder, which is vertical.

The effect of the corresponding isostatic compensation was computed from the same formula (17) with the same values of c and h, but with $t=11\ 370\ 000$ centimeters, the assumed depth of compensation (it should be remembered that compensation is assumed to begin at the surface of the ground and at the bottom of the sea, see page 10), and with a value of δ_1 from formula (3), page 8, substituted for δ, namely, $\delta_1=\delta\frac{H}{h_1}=2.67\frac{H}{11\ 370\ 000}$, in which H is the elevation of the surface above sea level (assumed to be the same as the elevation of the station).

The isostatic compensation is thus treated as a cylinder of material of a negative density δ_1, or, in other words, as a negative mass just equal to the positive mass which would exist in this zone above sea level if the actual density of all material in the zone above sea level were 2.67.

For a land compartment the computed effect of the topography is positive, an increase in the downward attraction upon a unit mass (1 gram) at the station. The computed effect of the isostatic compensation is negative, a decrease in the downward attraction upon a unit mass at the station. The difference of the two is the resultant effect of the combined topography and isostatic compensation. This resultant effect was computed for various assumed values of the elevation of the station above sea level, and then the reduction table for zone A written as shown on page 30. An inspection of the table will make it clear that as soon as a few of the tabular values had been computed the remainder could be safely interpolated with the required degree of accuracy.

To apply formula (17) to a station at sea, such as those occupied by Dr. Hecker on the Atlantic and Pacific,* it is necessary in computing the effect of the topography to substitute for δ in formula (17) the value $(\delta - \delta_w)$ (see pp. 8–9, and illustration No. 2), the defect of density of sea water in comparison with solid earth. The value of h is zero, the station being assumed to be at sea level. The mass thus considered is a mass which is the difference between that actually contained in the cylinder of radius 200 centimeters extending from the station at sea level down to the bottom of the ocean, and the mass which would fill this same cylinder if solid earth with a density of 2.67 were substituted for the sea water.

To apply formula (17) to a station at sea, in computing the effect of the isostatic compensation, it is necessary to substitute for the δ of formula (17) the value of δ_1 computed by formula (6a), page 11, namely

$$\delta_1 = \delta \frac{0.615\ D}{h_1} = 2.67 \frac{0.615\ D}{11\ 370\ 000}$$

in which D is the depth of the water. In this case the h of formula (17) is not zero but equal to D, as the upper limit of the compensation is at the ocean bottom at a distance D below the station.

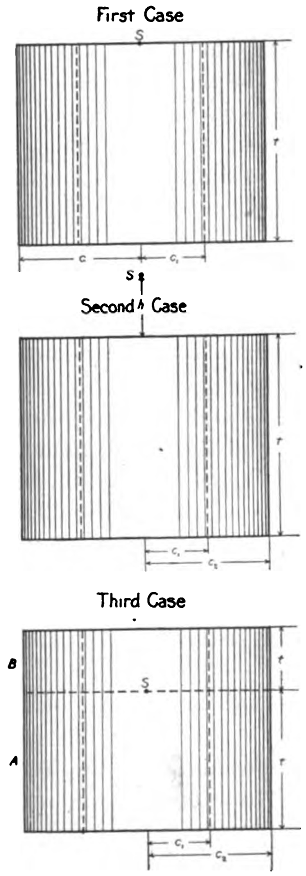

Illustration No. 6.—Showing topography in land zones—three cases.

For an oceanic compartment the computed effect of the topography (in this case submerged topography, or hydrography) is negative, a decrease in the downward attraction upon a unit mass at the station. That is, the attraction is less than it would be if in the compartment from the ocean bottom to sea level material of density 2.67 were substituted for the sea water which is actually in this space. The computed effect of the isostatic compensation is positive, an increase in the downward attraction upon a unit mass at the station, for the compensation is in this case an excess of density and of mass. The resultant effect is in this case again a numerical difference.

Similarly formula (18) was used in computing the reduction tables for zones B to O inclusive. It was used separately for the topography and the isostatic compensation, and the results were also combined. The values for the δ of formula (18) were the same as have been stated already in connection with the application of formula (17).

In using formula (18) to compute the effect of the topography in land zones three cases arise.

First, when the mean elevation of the surface of the ground in the zone is the same as the elevation of the station, h is zero in formula (18). (See illustration No. 6.) In this case the attracted point, the station, is in the plane of the upper end of the cylindrical shell considered. This cylindrical shell contains all the material in the zone, from the actual surface of the ground down to sea level, the inner and outer radii of the shell being the same as the inner and outer radii of the zone, and the length of an element of the cylindrical shell being the mean elevation of the surface of the ground.

Second, when the station is above the mean elevation of the surface of the ground in the zone, as indicated in the second case in illustration No. 6, h is the difference of elevation between the station and the mean surface of the ground in the zone, and in other respects this case is similar to the first one. For any land zone the computed effect of the topography in either the first or the second case is always positive, an increase in the downward attraction at the station.

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* Bestimmung der Schwerkraft / auf dem / Atlantischen Ozean / Sowie in / Rio de Janeiro, Lissabon und Madrid / Mit Neun Tafeln / von O. Hecker; Berlin, 1903. Bestimmung der Schwerkraft / auf dem / Indischen und Groszen Ozean / und / An Deren Küsten / Sowie Erdmagnetische Messungen / Mit Zwölf Tafeln. / von Prof. Dr. O. Hecker; Berlin, 1908.

Third, when the station is below the mean elevation of the surface of the ground in the zone, as indicated in the third case in illustration No. 6, the cylindrical shell containing the topography is considered broken into two separate cylindrical shells, one above the other, indicated as shell *A* and shell *B* in the illustration, and formula (18) is applied separately to the two shells. Shell *A* extends from sea level to the elevation of the station, and its effect is computed exactly as was that of the shell in the first case. Shell *B* contains the remainder of the material in the zone above sea level. It extends from the level of the station up to the mean elevation of the surface of the ground in the zone. In this shell c_2 and c_1 have the same values as in shell *A*, h is zero, the station being in the plane of the lower end of the shell, and t is the difference between the elevation of the station and the mean elevation of the surface of the ground in the zone. The effect of the material in shell *B* is an upward attraction at the station. Hence the resultant effect at the station of the topography in this case is the difference of the separate effects of shell *A* and shell *B*. This resultant effect will evidently be positive, a downward attraction, if shell *A* is longer than shell *B*, and will be negative if shell *B* is the longer. If the station is at an elevation exactly one-half of the mean elevation of the surface of the ground in the zone, shell *A* and shell *B* are of equal lengths, and the resultant effect is zero.

For oceanic zones the first and second cases arise, but never the third case. Hence for oceanic zones the computed effect is always negative, the downward attraction at the station being always less than it would be if material of density 2.67 were substituted for sea water.

In applying formula (18) to the computation of the effect of the isostatic compensation for land zones all three of the cases described above arise. Hence, in the third case, the effect of the compensation was obtained by computing separately the effects of two shells corresponding to shell *A* and shell *B*. In computing the effect of the compensation the length of an element of the shell is 11 370 000 centimeters (the depth of compensation) in the first and second cases, 11 370 000 centimeters minus the difference between the elevation of the station and the mean elevation of the ground in the zone in shell *A* of the third case, and simply the difference between the elevation of the station and the mean elevation of the surface of the ground in the zone in shell *B* of the third case. In all these cases, including both shells in the third case, the value to be used for δ in formula (18) is that computed from formula (3), page 8, in which the mean elevation of the surface of the zone is to be used for H and the assumed depth of compensation for h_1. As shell *A* is always much longer than shell *B* in connection with the compensation, its effect always predominates, and the computed effect of the compensation for these zones is always negative, a decrease of downward attraction at the station.

In applying formula (18) to the computation of the effect of the isostatic compensation for oceanic zones the second case is the only one which arises, and the computed effect of the compensation is always positive, an increase in the downward attraction at the station. The value to be used for δ in formula (18) is computed from formula (6*a*), page 11.

For zones *B* to *O* the combined effect of topography and compensation is not always a numerical difference of the separate effects. In a few rare cases for land zones, namely, when shell *B* of the third case happens to be longer than shell *A*, the effects at the station of the topography and its compensation are both negative, and their combined effect is the numerical sum.

To avoid circumlocutions a few paragraphs just preceding this have been worded as if the mean elevation for the whole of each zone was dealt with in the computation. In zone F, see page 18, which is divided into 10 equal compartments, the effect of the topography or of the compensation in any one compartment upon the vertical component of the attraction at the station is evidently exactly one-tenth of that computed for the whole zone from formula (18), provided the elevation of the surface of the ground is the same throughout the zone. The actual practice was to use formula (18) in computing the effects for a whole zone at once, then to divide the result by the number of compartments in that zone (10 for zone F) to obtain the effect of each compartment. These effects for separate compartments were then tabulated in the reduction tables, and in using these tables the mean elevation for each compartment was used, not the mean elevation for the whole zone.

It was not found necessary to compute each separate value in the reduction tables for zones B to O. For each of these tables a few scattered values, in each of several selected columns, were computed. For each selected column the points so computed were plotted on cross-section paper, using the assumed mean elevation of the compartments as abscissæ and the computed values as ordinates. When the number of plotted points was sufficient to enable one to do so with the required degree of accuracy, a curve was drawn through these points to represent all the required values corresponding to the column in question. The intermediate values for the column were then scaled from the curve and entered in the table, together with the computed values. After the values in a few columns of the table had been so obtained, it obviously became possible to interpolate the values for the remaining columns with the required degree of accuracy. The vertical differences in the columns, filled in from the computations and curves, served as checks in making these interpolations.

Illustration No. 7 shows the curves used as indicated above in connection with the reduction table for zone E. On each curve the computed points are indicated by small circles. The curves were drawn by eye, using a draftsman's flexible ruler. The shape of each curve and its position relative to the other curves furnish a sensitive check for detecting errors in the plotted values due to the computations or plotting.

As the computations of the reduction tables by formula (18) could be made much more easily than by formulæ (10), (15), and (16), it was desired to extend the use of formula (18) to as many zones as possible. It was found that out to zone L the errors secured by the use of formula (18) in the manner already described were within allowable limits. It appeared that when formula (18) was applied to zone O the principal error arose from the fact that a point in the middle of this zone which is at the same elevation as the station lies 4500 feet below the horizontal plane of the station on account of the curvature of the sea-level surface. It appeared that possibly this particular error could be eliminated and a very close approximation to the truth obtained by using for the h of formula (18) not the difference of elevation between the station and the mean surface of the ground in the zone, but instead the difference of elevation between the station and a point 4500 feet below the mean elevation of the zone. This would have the effect of making the second correction in the table zero if the mean surface of the compartment lay in the horizontal plane of the station. Accordingly, the column headed "Station above compartment, 800 feet," in the reduction table for zone O, was computed with a value $4500+800=5300$ feet for h, the next column with a value $4500+1600=6100$ feet for h, and so on. Similarly the values in the column headed "Station below compartment, 800 feet," were computed with the value $4500-800=3700$ feet. The corrections in the column headed "Station at same elevation as compartment" are applicable to compartments in which the mean elevation of the surface of the ground is the same as that of the station. These values were computed with $h=4500$ feet in formula (18).

Similar modifications to take account of the curvature approximately were made in the tables for zones M and N, but for zones nearer the station it appeared that such changes would not amount to as much as 0.0001 dyne, and they were therefore not computed.

After computations for zone O were made by formula (18), using the modified method indicated in the preceding two paragraphs, in which method the curvature of the sea-level surface is taken into account in part, certain values of the table were also computed by formulæ (10), (15), and (16), which are exact, the curvature being fully taken into account. This test showed that the tabular values as computed by formula (18) by the method described are each within 0.0002 dyne, and are in error by less than 1 part in 200 on an average. This made it certain that the errors in zones M and N, and other zones nearer the station than zone O, are well within the adopted limits. The test in zone O also indicated that for the next larger zone the adopted limits of error might be exceeded if formula (18) were used, even with the modification described. Therefore formulæ (10), (15), and (16) were used for all zones beyond O.

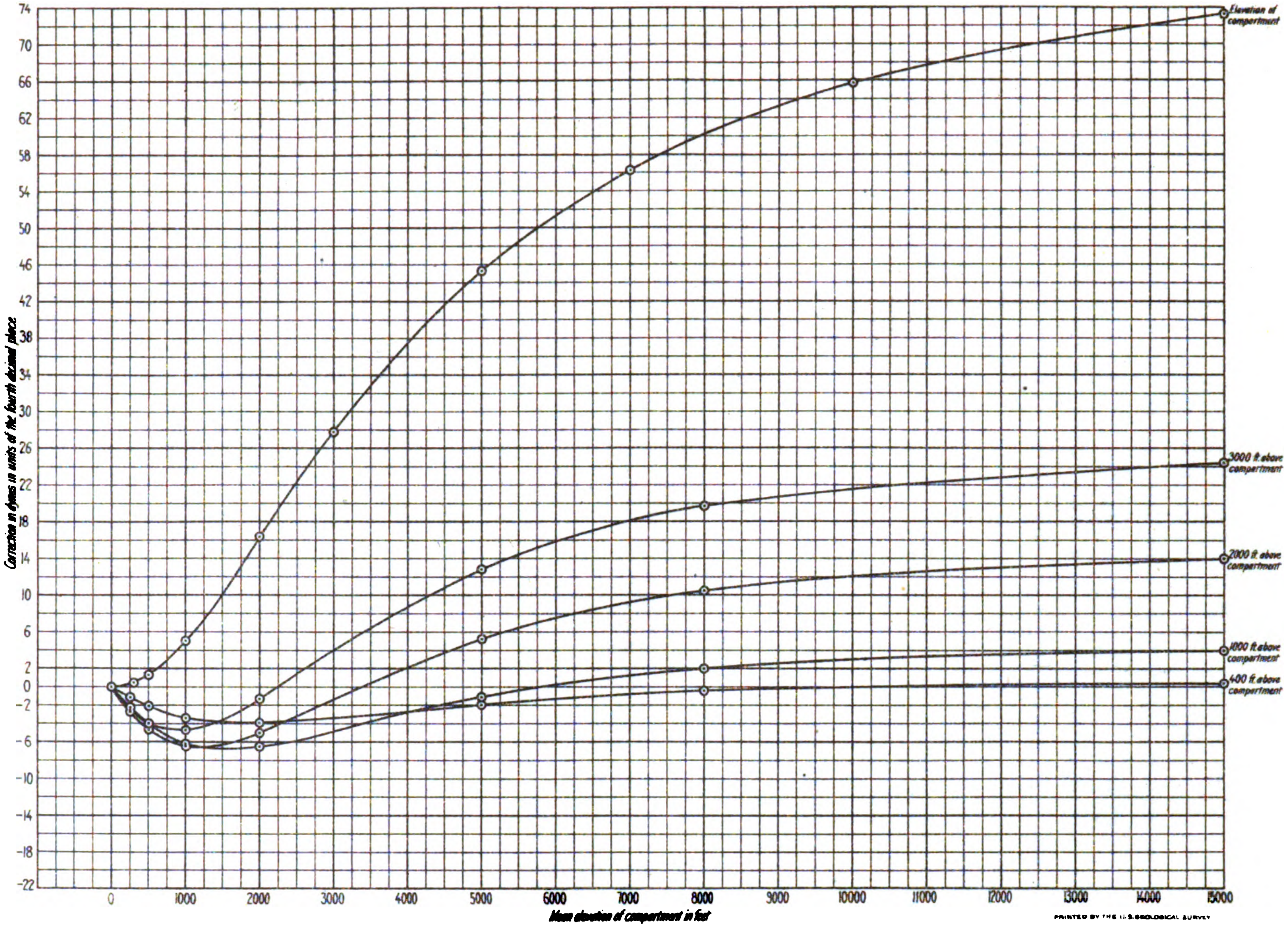

ILLUSTRATION No. 7.—Graphical Computation of Reduction Table for Zone E.

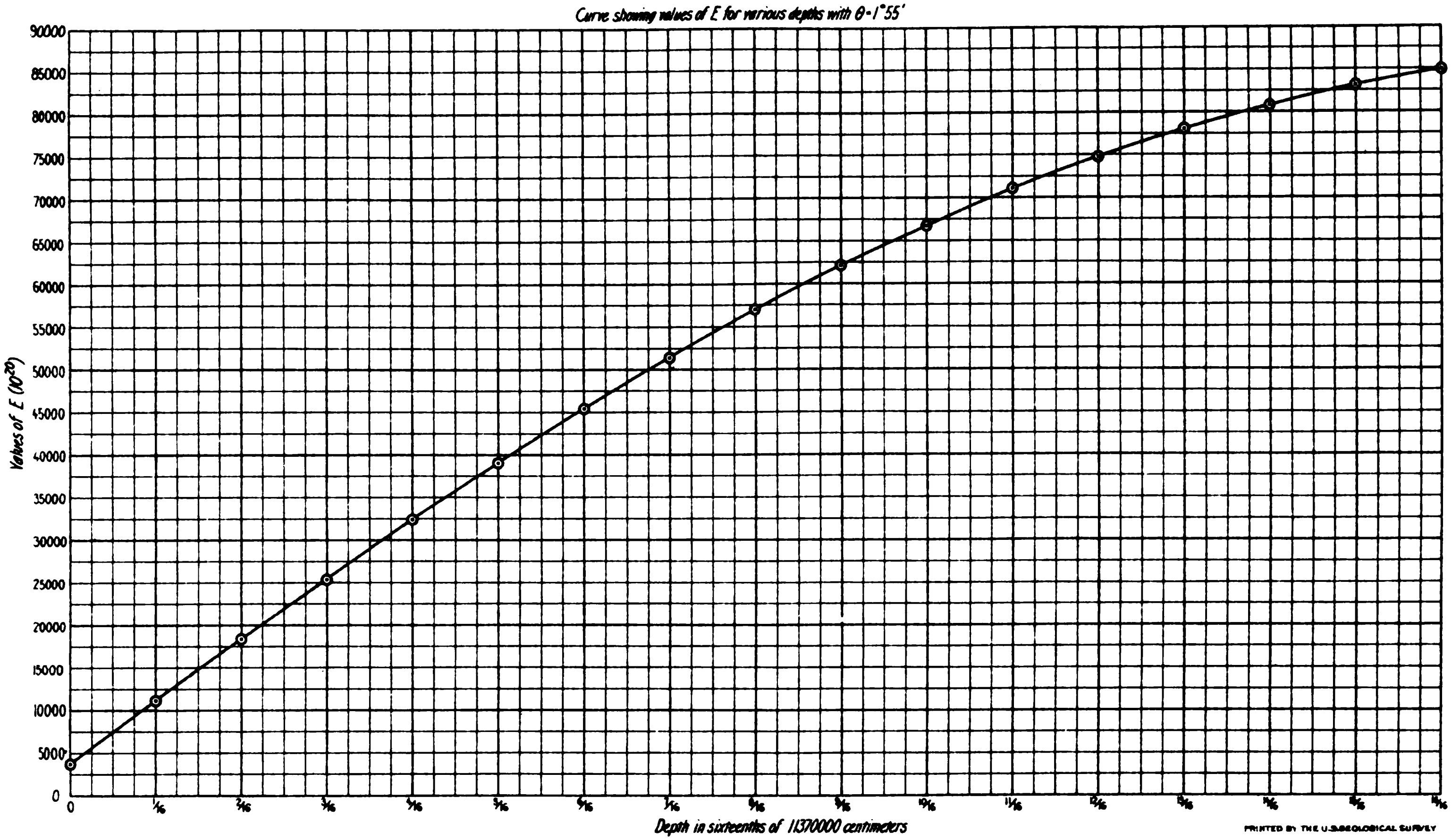

ILLUSTRATION No. 8.—GRAPHICAL REPRESENTATION OF VALUES OF E FOR VARIOUS DEPTHS.

COMPUTATION OF REDUCTION TABLES FOR DISTANT ZONES.

To use these formulæ in computing the effect of the topography within a given zone for a land area it is necessary to integrate the expression $kdmE$ to include all elementary masses within that zone between the surface of the ground and sea level. E is understood in this statement to be the E of formula (10), the E_1 of formula (15), or the E_2 of formula (16) for each elementary mass according to whether it is at the same level as the station, higher than the station or lower than the station, respectively. Since $kdmE$ is the vertical component of the attraction in dynes upon a unit mass at the station due to an elementary mass, dm, the integral stated is evidently the vertical component of the attraction due to all the elementary masses which combined constitute the material lying above sea level in the zone in question. In the integration k is a constant, and the sum of all the elementary masses, dm, is the total mass m, which is known in terms of the volume and density. No difficulty was encountered in dealing with these quantities. But the expression for E is a function of h and θ, which can not, so far as the writers know, be directly integrated with respect to these quantities by calculus. Therefore, an integration by numerical computation was made.

The vertical component of the attraction in dynes upon a unit mass at the station due to all the topography within any zone lying entirely in a land area was therefore expressed as the integral of $kdmE$ or

$$km \text{ (average value of } E \text{ for the zone)} \tag{19}$$

in which it is understood that the various values of E, of which the average is taken, must correspond to equal elementary masses, of which the sum is m, the total mass represented by the topography in the zone.

Similarly the vertical component of the attraction in dynes upon a unit mass at the station due to the isostatic compensation of the topography within any zone lying entirely in a land area is also represented by formula (19). The negative mass involved is m, the values of E are those fixed by the direction and distance of the compensation from the station, and h is made to vary to cover the whole range occupied by the compensation, namely, from sea level down to the depth 113.7 kilometers below that surface.

The effect of the topography and the effect of its compensation might have been computed separately from formula (19), but it was believed that greater rapidity would be secured without loss of accuracy by combining and dealing directly with the resultant difference of the effects of the topography and its compensation. Accordingly, the actual process followed is that described in the following paragraphs.

The computation will be described first for land zones having an elevation of 100 feet and for the station assumed to be at sea level. The modifications introduced for other elevations, for ocean zones, and for assumed positions of the station above sea level will be stated later.

For a selected value of θ, E was computed by formulæ (10) and (16) for several equally spaced values of h, varying from zero to the depth of compensation. Let the required mean value of an infinite number of such equally spaced values, covering the depth of compensation, be called E_c. By successive trials with increasing numbers of equally spaced values of h it was ascertained how many values were necessary in order to secure the required degree of accuracy in the mean value, E_c, corresponding to the selected value of θ. As E varies continuously according to a law which may be graphically expressed by a smooth and regular curve, it was not difficult with the numerical values at hand to make certain that one had secured the required degree of accuracy. Illustration No. 8 is an example of such a curve, which corresponds to $\theta = 1° 55'$; that is, to compensation which lies in a part of zone 16. (See page 18.) The values of h are plotted as abscissæ and the corresponding values of E as ordinates. The small circles each represent a computed value of E. A smooth curve has been drawn by eye through these computed points. It is evident that as the curve is nearly a straight line between successive computed points but little change would be secured in the mean by computing more points. This is still more clearly and precisely shown in the following table, corresponding to illustration No. 8, and showing the computed values of E and their first and second differences.

Values of E for various depths, with $\theta = 1° 55'$.

Depth	$E(10^{20})$	Difference	Second difference
Centimeters			
0	3684		
1/16×11 370 000	11 026	+7342	− 60
2/16×11 370 000	18 308	+7282	−133
3/16×11 370 000	25 457	+7149	−209
4/16×11 370 000	32 397	+6940	−255
5/16×11 370 000	39 082	+6685	−332
6/16×11 370 000	45 435	+6353	−354
7/16×11 370 000	51 434	+5999	−409
8/16×11 370 000	57 024	+5590	−454
9/16×11 370 000	62 160	+5136	−462
10/16×11 370 000	66 834	+4674	−477
11/16×11 370 000	71 031	+4197	−499
12/16×11 370 000	74 729	+3698	−433
13/16×11 370 000	77 994	+3265	−485
14/16×11 370 000	80 774	+2780	−473
15/16×11 370 000	83 081	+2307	−431
11 370 000	84 947	+1876	
Mean	52 568		

If an infinite number of points were computed on the curve shown in illustration No. 8 and the mean taken, instead of the mean of the finite number of points there shown, the change in the computed mean would be represented by the average ordinate included between the curve and the series of chords joining the computed points which are shown in the illustration. As a convenient rough guide it was assumed that this average ordinate would usually be less than one-eighth of the average second difference shown in the preceding table. That this ratio, one-eighth, is a reasonably safe assumption in such a case may be verified either by trial or by geometry, assuming the short portion of the curve between successive points to be an arc of a circle.

A similar process of reasoning was followed to obtain the mean value of E corresponding to the topography for the same selected value of θ. Let E_T be the required mean value of an infinite number of equally spaced values covering the range from zero to the arbitrarily selected elevation, 100 feet. After E had been computed from formulæ (10) and (15) it usually appeared that in order to secure a sufficiently exact value of E_T it was necessary to compute but two values, one for $h = o$ and one for $h = 100$ feet, the mean of these two being sufficiently accurate.

It will be shown later how topography of a greater elevation than 100 feet was dealt with.

Keeping in mind that the negative mass, which is the isostatic compensation, is necessarily exactly equal to the positive surface excess of mass, which is the topography, formula (19) as applied to the topography and the compensation combined may be written

$$km(E_T - E_C) \text{ or } km\ E_R \qquad (20)$$

E_R being written for $E_T - E_C$.

As this process of computing E_R, corresponding to a selected value of θ, is slow it was important to use good judgment in selecting the various values of θ for which the computation was to be made. It was desired to obtain a sufficiently accurate value of E_R for every possible value of θ by computing a moderate number of values for selected values of θ. At first E_R was computed for $\theta = 180°$, that is for the antipodes of the station, and for $\theta = 90°$, midway between the station and its antipodes. Then the computation was made for a few more values of θ at large intervals. It soon became evident that E_R varies quite slowly and at nearly a uniform rate if θ is near 180°, but that for small values of θ, E_R varies at a large and rapidly changing rate. Therefore, to secure a given degree of accuracy in interpolated values it was evidently necessary to compute E_R for closely spaced small values of θ, but only for widely separated large values of θ. The following table shows the various values of E_R actually computed. The values of θ shown in this table were selected by inspection by a step by step process, computations being made first for two values only of θ as already stated, then for values spaced at intervals of 30°, then at intervals of 10° for smaller values only, at intervals of 5° for still smaller values, and so on. All values of E_R intermediate between those shown in the table were obtained by interpolation. Illustration No. 9 shows a part of this table expressed graphically.

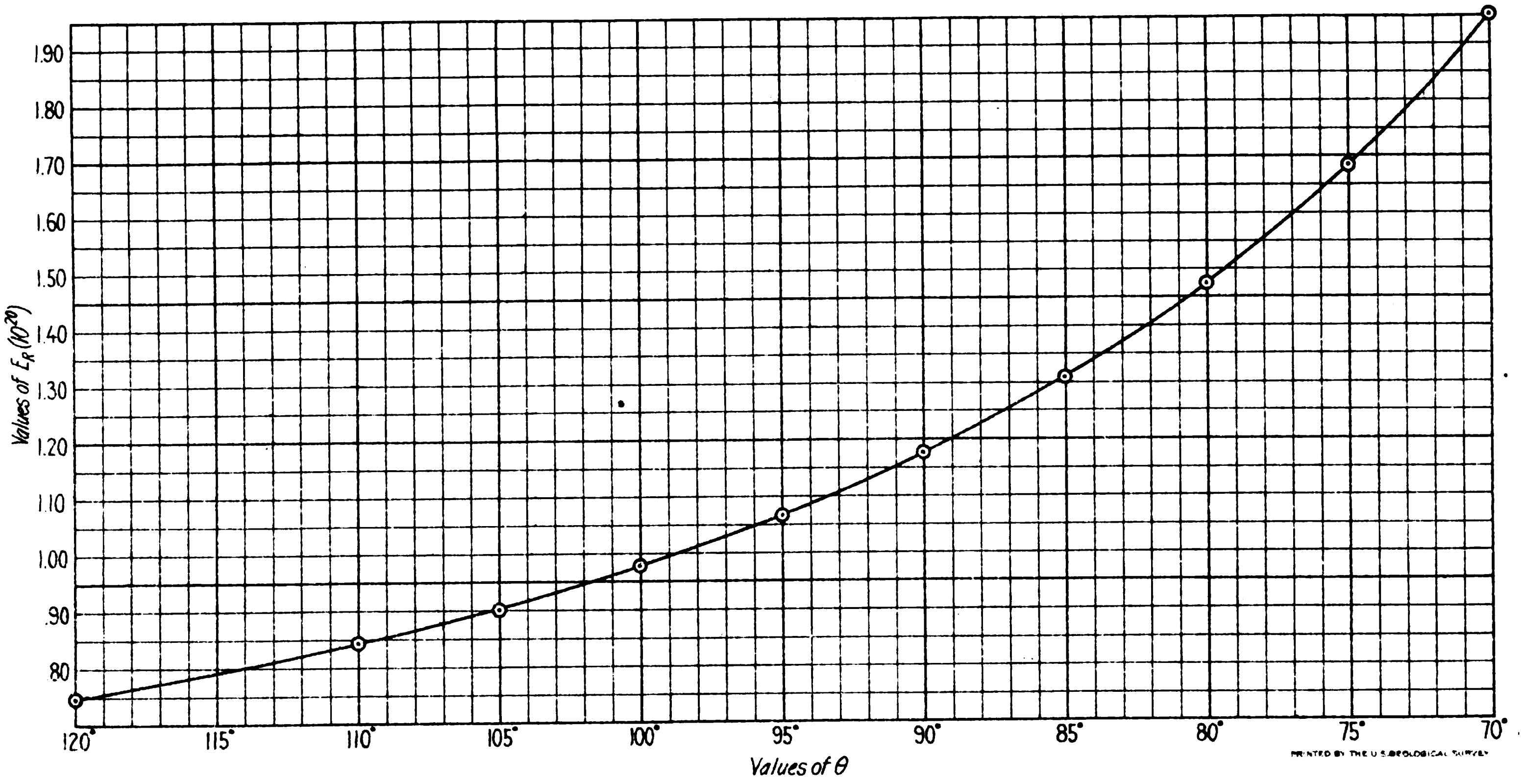

ILLUSTRATION No. 9.—GRAPHICAL REPRESENTATION OF VALUES OF E_R.

θ	E_T (10^{20})	E_C (10^{20})	E_R (10^{20})	θ	E_T (10^{20})	E_C (10^{20})	E_R (10^{20})
° ′				° ′			
180 00	+61.6112	−62.1664	−0.5552	11 30	+614.9	−892.6	−277.7
170 00	+61.8466	−62.4057	−.5591	11 00	+642.8	−959.3	−316.5
160 00	+62.5618	−63.1336	−.5718	10 30	+673.2	−1035.8	−362.6
150 00	+63.7846	−64.3793	−.5947	10 15	+689.6	−1079.1	−389.5
140 00	+65.5654	−66.1943	−.6289	10 00	+706.8	−1125.8	−419.0
130 00	+67.9805	−68.6586	−.6781	9 45	+724.8	−1177.2	−452.4
120 00	+71.1425	−71.8894	−.7469	9 30	+743.9	−1232.8	−488.9
110 00	+75.2134	−76.0565	−.8431	9 15	+763.9	−1293.7	−529.8
105 00	+77.6592	−78.564	−.905	9 00	+785.2	−1359.6	−574.4
100 00	+80.4277	−81.4071	−.9794	8 45	+807.5	−1432.2	−624.7
95 00	+83.566	−84.634	−1.068	8 30	+831.2	−1512.1	−680.9
90 00	+87.1314	−88.3089	−1.1775	8 15	+856.3	−1599.9	−743.6
85 00	+91.196	−92.506	−1.310	8.00	+883.0	−1697.1	−814.1
80 00	+95.8500	−97.326	−1.476	7.45	+911.4	−1805.3	−893.9
75 00	+101.208	−102.892	−1.684	7 30	+941.8	−1925.9	−984.1
70 00	+107.416	−109.368	−1.952	7 15	+974.2	−2061.3	−1087.1
65 00	+114.668	−116.972	−2.304	7 00	+1008.9	−2213.3	−1204.4
60 00	+123.222	−125.994	−2.772	6 45	+1046	−2391	−1345
59 00	+125.118	−128.004	−2.886	6 30	+1086	−2593	−1507
58 00	+127.083	−130.088	−3.005	6 15	+1130	−2823	−1693
57 00	+129.120	−132.254	−3.134	6 00	+1176	−3087	−1911
56 00	+131.235	−134.505	−3.270	5 45	+1228	−3394	−2166
55 00	+133.430	−136.848	−3.418	5 40	+1246	−3506	−2260
54 00	+135.710	−139.284	−3.574	5 35	+1264	−3624	−2360
53 00	+138.080	−141.823	−3.743	5 30	+1284	−3750	−2466
52 00	+140.545	−144.470	−3.925	5 25	+1304	−3881	−2577
51 00	+143.111	−147.232	−4.121	5 20	+1324	−4020	−2696
50 00	+145.784	−150.115	−4.331	5 15	+1344	−4165	−2821
49 00	+148.570	−153.128	−4.558	5 10	+1366	−4320	−2954
48 00	+151.476	−156.278	−4.802	5 05	+1388	−4482	−3094
47 00	+154.511	−159.578	−5.067	5 00	+1412	−4658	−3246
46 00	+157.681	−163.037	−5.356	4 55	+1436	−4849	−3413
45 00	+160.996	−166.666	−5.670	4 50	+1460	−5056	−3596
44 00	+164.468	−170.482	−6.014	4 45	+1486	−5271	−3785
43 00	+168.106	−174.493	−6.387	4 40	+1512	−5503	−3991
42 00	+171.920	−178.717	−6.797	4 35	+1540	−5743	−4203
41 00	+175.926	−183.172	−7.246	4 30	+1568	−6007	−4439
40 00	+180.138	−187.877	−7.739	4 25	+1598	−6287	−4689
39 00	+184.569	−192.851	−8.282	4 20	+1628	−6582	−4954
38 00	+189.240	−198.123	−8.883	4 15	+1660	−6896	−5236
37 00	+194.168	−203.716	−9.548	4 10	+1694	−7237	−5543
36 00	+199.376	−209.664	−10.288	4 05	+1728	−7601	−5873
35 00	+204.89	−216.00	−11.11	4 00	+1764	−7986	−6222
34 00	+210.72	−222.76	−12.04	3 55	+1801	−8425	−6624
33 00	+216.92	−230.00	−13.08	3 50	+1840	−8883	−7043
32 00	+223.52	−237.76	−14.24	3 45	+1881	−9385	−7504
31 00	+230.54	−246.10	−15.56	3 40	+1924	−9943	−8019
30 00	+238.04	−255.10	−17.06	3 35	+1968	−10525	−8557
29 00	+246.06	−264.83	−18.77	3 30	+2014	−11165	−9151
28 00	+254.66	−275.38	−20.72	3 25	+2064	−11903	−9839
27 00	+263.92	−286.89	−22.97	3 20	+2115	−12685	−10570
26 00	+273.88	−299.46	−25.58	3 15	+2170	−13526	−11356
25 00	+284.65	−313.27	−28.62	3 10	+2226	−14457	−12231
24 00	+296.32	−328.51	−32.19	3 05	+2286	−15462	−13176
23 00	+309.02	−345.40	−36.38	3 00	+2350	−16567	−14217
22 00	+322.88	−364.24	−41.36	2 55	+2416	−17829	−15413
21 00	+338.08	−385.40	−47.32	2 50	+2487	−19214	−16727
20 00	+354.79	−409.32	−54.53	2 45	+2562	−20736	−18174
19 30	+363.80	−422.48	−58.68	2 40	+2642	−22480	−19838
19 00	+373.27	−436.60	−63.33	2 35	+2726	−24402	−21676
18 30	+383.27	−451.69	−68.42	2 30	+2817	−26530	−23713
18 00	+393.82	−467.96	−74.14	2 25	+2914	−28970	−26056
17 30	+404.98	−485.47	−80.49	2 20	+3018	−31703	−28685
17 00	+416.80	−504.39	−87.59	2 15	+3128	−34855	−31727
16 30	+429.34	−525.04	−95.70	2 10	+3248	−38370	−35122
16 00	+442.6	−547.4	−104.8	2 05	+3377	−42524	−39147
15 30	+456.8	−571.9	−115.1	2 00	+3516	−47164	−43648
15 00	+472.0	−598.7	−126.7	1 55	+3668	−52568	−48900
14 30	+488.2	−628.2	−140.0	1 50	+3833	−58930	−55097
14 00	+505.6	−660.6	−155.0	1 45	+4014	−66117	−62103
13 30	+524.2	−697.2	−173.0	1 40	+4212	−74671	−70459
13 00	+544.2	−737.5	−193.3	1 35	+4431	−84735	−80304
12 30	+565.8	−782.6	−216.8	1 30	+4674	−96711	−92037
12 00	+589.4	−834.4	−245.0	1 25	+4945	−110993	−106048

It was desired that each value of E_R used in the computation, whether obtained directly or by interpolation, must be correct within 1 part in 200.

Having sufficiently accurate values of E_R for each separate value of θ the next step is essentially an integration with respect to θ as the variable.

The area of any zone lying between the limiting values of θ, θ_1, and θ_2, on the surface of the sphere which is being considered, one having a radius of 637 000 000 centimeters (see p. 15) is

$$2\pi r^2 (\cos \theta_1 - \cos \theta_2) \qquad (21)$$

or $(6.283186)(637000000)^2(\cos \theta_1 - \cos \theta_2)$

Hence for this zone formula (20) becomes

$$k\delta H\,[(6.283186)(637000000)^2(\cos \theta_1 - \cos \theta_2)]\ (\text{mean value of } E_R \text{ for the zone}) \qquad (22)$$

in which for m there has been substituted its value in terms of density and volume, namely, δH(area).

With the numerical values before one it is not difficult to determine that for zones of a moderate width the average value of E_R for the zone is with sufficient accuracy the mean of its values at the two edges of the zone corresponding to θ_1 and θ_2. Therefore, formula (22), which is an expression for the required vertical component of the attraction in dynes upon a unit mass at the station due to the combined effect of both the topography and its isostatic compensation lying in a zone, may be evaluated by making separate numerical computations for separate narrow zones and adding the values.

By examination of the table showing values of E_R it is evident that the separate zones which may be used in this process are wide near the antipodes and decrease in width as θ becomes smaller. The actual widths used did not exceed the following limits and were occasionally less.

Limits of widths of subzones.

θ	Limit of width of subzone
° ′ ° ′	° ′
180 00 to 72 00	2 00
72 00 to 20 00	1 00
20 00 to 10 30	0 30
10 30 to 5 40	0 15
5 40 to 1 25	0 05

It was known from a reconnoissance of the problem that for all distant zones (beyond $\theta = 1° 29' 58''$) the value of the attraction computed from formula (22) would be nearly proportional to H. Therefore, as a time-saving device, it was decided to determine such widths for the selected zones and fix the number of compartments in each zone so that an attraction of 0.0001 dyne for any one compartment would correspond to a value for H of either 100, 1000, or 10 000 feet in that compartment. In that case the computation would consist simply of estimating the mean elevation within the compartment in feet and moving the decimal point a certain number of places to the left to obtain the attraction in dynes.

The arbitrarily selected unit of elevation corresponding to 0.0001 dyne was 10 000 feet for zones 1 to 6 (see tables on pp. 44–46), 1000 feet for zones 7 to 13, and 100 feet for zones 14 to 18. The number of compartments in each zone was arbitrarily fixed as shown in the same tables. By formula (22) the width of the zone was computed which would satisfy the condition that the attraction in one compartment corresponding to a unit of elevation was exactly 0.0001 dyne. For example, for zone 3 having 10 compartments it must be 0.0010 dyne for the zone if the mean elevation in the zone is 10 000 feet.

No difficulty was found in making this computation. An example of the actual arrangement of the numerical work is shown below for zone 12 having 10 compartments.

gravitation constant × these

Computation of limit of zone 12.

[$km.=k\delta H$=0.00543061 for H=1000 feet.]

θ_1 to θ_2	$\cos\theta_1-\cos\theta_2$	Area in cm × (10^{-20})	Area × km × (10^{-20})	E_R (10^{20})	Area × km × E_R
° ′ ″ ° ′ ″					
5 46 34 to 5 40 00	0.0001905	0.000004857	0.00000002638	2198	0.00005798
5 40 00 to 5 35 00	.0001425	.000003633	.00000001973	2310	.00004558
5 35 00 to 5 30 00	.0001405	.000003582	.00000001945	2413	.00004693
5 30 00 to 5 25 00	.0001383	.000003526	.00000001915	2522	.00004830
5 25 00 to 5 20 00	.0001363	.000003475	.00000001887	2636	.00004974
5 20 00 to 5 15 00	.0001341	.000003419	.00000001857	2758	.00005122
5 15 00 to 5 10 00	.0001321	.000003368	.00000001829	2888	.00005282
5 10 00 to 5 05 00	.0001299	.000003312	.00000001799	3024	.00005440
5 05 00 to 5 00 00	.0001278	.000003258	.00000001769	3170	.00005608
5 00 00 to 4 55 00	.0001257	.000003205	.00000001741	3330	.00005798
4 55 00 to 4 50 00	.0001236	.000003151	.00000001711	3504	.00005995
4 50 00 to 4 45 00	.0001215	.000003098	.00000001682	3690	.00006207
4 45 00 to 4 40 00	.0001194	.000003044	.00000001653	3888	.00006427
4 40 00 to 4 35 00	.0001173	.000002991	.00000001624	4097	.00006654
4 35 00 to 4 30 00	.0001151	.000002934	.00000001593	4321	.00006883
4 30 00 to 4 25 00	.0001131	.000002884	.00000001566	4564	.00007147
4 25 00 to 4 20 00	.0001109	.000002827	.00000001535	4822	.00007401
4 20 00 to 4 19 12	.0000176	.000000449	.00000000244	4987	.00001217
					Sum=0.00100034

The change for 1″ is about 0.000 000 25, therefore, the inner limit of zone 12 is, to the nearest second, 4° 19′ 13″. With that limit the above sum becomes 0.001 000 34 − 0.000 000 25 = 0.001 000 09.

The basis for the arbitrary decisions as to unit elevations and number of compartments in each zone will be indicated under the topic "Discussion of errors." It suffices to state here that the selection was guided by the desirability of making the computations as rapidly as possible subject to the chosen standard of accuracy. Errors of judgment in one direction would make the computation slow, and in the opposite direction would make the computation too inaccurate.

The limits of zones 1 to 18 computed as indicated above are shown in the reduction tables on pages 44–46, as well as on page 18.

To apply formula (22) to the computation for oceanic zones it was necessary merely to take into account the fact that the defect of density represented by sea water is $\delta-\delta_w=0.615\ \delta$. (See p. 9.) Therefore, if the unit of elevation is 10 000 feet for a land compartment, corresponding to an attraction of 0.0001 dyne, it will be for an oceanic compartment to produce the same effect

$$\frac{10\ 000\text{ feet}}{0.615}=16\ 260\text{ feet}=2710\text{ fathoms}.$$

Hence the unit of depth shown for zones 1 to 18 in the reduction tables on pages 44–46.

The attraction computed from formula (22) for a given compartment is not strictly proportional to H as assumed for a first close approximation. The limits of h used in computing E_R must correspond to H. For a land compartment, as H is made greater E_T becomes smaller, as it is an average value covering larger values of h in formula (15). Also as H, the assumed elevation, is made greater E_c tends to become smaller, for the isostatic compensation is assumed to commence at the solid surface of the ground (above sea level) (see illustration No. 2, page 10), and to extend to a depth of 113.7 kilometers measured from that level. The limits of h used in formulæ (15) and (16) must be fixed accordingly. Similar modifications must be inserted for oceanic compartments, the compensation commencing in this case at the ocean bottom, not at the sea level. As E_T and E_c, and their difference E_R, vary slightly for different values of H, the computed attractions in formula (22) are not strictly proportional to H as they would be if E_R were independent of H. This departure from strict proportionality was found upon investigation to be inappreciable for zones 1 to 13. For zones 14 to 18 a few special computations were made to evaluate the corrections for departure from proportionality shown in the reduction tables on page 44. These special computations were made by using the proper limiting values of h as indicated above, comparing the computed values with the values based on the assumption of proportionality and the original computations with $h = 100$ feet, and tabulating the differences as shown in the reduction tables. A few computations only were necessary because the corrections were small, and regular in their variation.

It was also assumed in order to secure a first close approximation to the attraction required that the station is at sea level. In general the station lies above sea level and, therefore, to secure exact results the values of h, used in formulæ (15) and (16) in computing E_T and E_C, must be differences of elevation between the station and the elementary mass, not merely the elevation of the elementary mass as was assumed in the first approximation. To secure the corrections for elevation shown in the reduction tables on page 44 a few special computations were made on the exact basis, compared with the first approximation, and the differences tabulated as corrections for elevation of the station. The corrections for elevation were found to be negligible for zones 1 to 13, and to be small as shown in the reduction tables for zones 14 to 18. Because the corrections are small and their variations regular but few special computations were necessary.

EXPLANATION OF REDUCTION TABLES.

The complete reduction tables for all the zones are given in the following pages. All tabular values are the vertical components of the attraction upon a unit mass at the station expressed in units of the fourth decimal place in dynes. It is equally true that these are corrections in units of the fourth decimal place of centimeters, to the acceleration of gravity, expressed in the centimeter-gram-second system.

These tables cover the whole of the earth's surface, from the station of observation to its antipodes. By their use one may quickly compute the effect upon the attraction of gravity, at any station on the earth, of all the topography of the earth and of its isostatic compensation assumed to be complete and uniformly distributed, with respect to depth, down to a limiting depth of compensation of 113.7 kilometers.

The radii of the zones A to O are given in meters, while those for zones 18 to 1 are in degrees, minutes, and seconds of an arc of a great circle.

The first column of each table from A to O contains values for the mean elevation of the compartment as read from the maps. The second, third, and fourth columns contain the corrections for the topography, the compensation, and the algebraic sum of the corrections for topography and the compensation respectively. These values are computed upon the assumption that the station is at the same elevation as the compartment. For zone A the elevation of the zone is necessarily that of the station, as its radius is only two meters. In the tables for zones B to O corrections for the elevation of the stations above or below the compartments are shown,

The corrections for the topography and compensation, the station being at the same elevation as the compartments, are shown separately in columns 2 and 3 for the zones out to O, in order that certain comparisons may be made between the effects of the assumption of complete local isostatic compensation and of regional isostatic compensation complete within a stated distance from the station. (See pp. 98–102.)

For the regular computations of the combined effect of topography and compensation, one correction is taken from column 4 of each table from zone A to zone O. For zone A this is the only correction. For zones B to L, inclusive, a second correction must be applied, as indicated to take account of the difference of elevation of the station and of the mean surfaces of the ground in the compartment. To the correction based upon the assumption that the station is at the same elevation as the compartment, taken from the fourth column of the table, is added algebraically the correction for elevation of station above or below the compartment in order to obtain the total effect of topography and compensation. Thus, in zone E, if the mean elevation of the surface of the ground in a compartment is 2000 feet, the first correction is +0.0016 dyne, and if in this case the elevation of the station is 3000 feet, 1000 feet above the compartment, the second correction is +0.0007 dyne, and the total effect of both the topography of this compartment and its isostatic compensation is to increase the vertical component of the attraction on a unit mass at the station by 0.0023 dyne.

It is understood that, for zones B to L, inclusive, the second correction, namely, for station above or station below compartment, is zero if the elevation of the station is the same as the mean elevation of the surface of the ground in the compartment. This fact is used in interpolation if necessary. For example, in the case just cited in zone E, in which the mean elevation of the surface of the ground in the compartment is 2000 feet, if the station happens to be 100 feet above the compartment, the second correction would be +0.0001 dyne, since the table indicates it to be +0.0002 if the station is 200 feet above, and it is understood to be zero if the station is at the same elevation as the compartment. Similarly, if in this case the station happens to be 100 feet below the compartment, the second correction would be −0.0001 dyne since the table shows it to be −0.0002 dyne if the station is 200 feet below the compartment.

For zones C to O the first column of the tables contains elevations in both fathoms and in feet. Those in fathoms are depths below sea level and are marked minus. The values in the second, third, and fourth columns, corresponding to depths in fathoms, are computed on the supposition that the station is at sea level and in the following columns, headed "Station above compartment," the station is assumed to be at the stated distances above sea level. Hence, for all water compartments, there will be two corrections in the regular computations, one from the fourth column and one from the proper column beyond the fourth. Thus, in zone E, if the mean depth in the water compartment is 200 fathoms, and the elevation of the station above sea level is 600 feet, the two corrections are −0.0004 dyne and −0.0002 dyne, and the total effect of both topography in this compartment and its isostatic compensation is to decrease the vertical component of the attraction on a unit mass at the station by 0.0006 dyne.

For zones M, N, and O, as already explained in connection with the computation of the tables (p. 22), the second correction does not necessarily become zero when the station is at the same elevation as the compartment. Instead it has the value shown in the tables for these zones in the extra column headed "Station at the same elevation as compartment." In taking out the second corrections for these three zones this extra column must be carefully noted, one must take the second correction from it when the station and compartment happen to be at the same elevation, and one must use the values in this column to control interpolations when the station and compartment are nearly at the same elevation. Thus, if the mean elevation of the surface of a compartment in zone M is 12 000 feet the second correction is +0.0001 if the station is also at the elevation 12 000 feet, it is between +0.0001 and +0.0002 if the station is less than 700 feet above the compartment, and it is between +0.0001 and −0.0002 if the station is less than 700 feet below the compartment.

For zones 18 to 14 three corrections are applied. The first is read directly from the map, being 0.0001 dyne for each unit of elevation, the unit in each case being 100 feet, as indicated in the heading of this table. The second is taken from the second column of the table, using the first correction as an argument in entering the table. It takes account of the slight departure of the actual correction from being strictly proportional to the elevation. The third correction is taken from the last part of the table and takes account of the correction due to the elevation of the station above sea level. Thus, in zone 17, if the correction as read from the map is −0.0100 dyne, the elevation of the zone (the zone has but one compartment) being 10 000 feet, then the correction for departure from proportionality is +0.0001, and if the elevation of the station above sea level is also 10 000 feet the correction for its elevation is +0.0003 and the total effect of topography and compensation of this zone, upon the vertical component of the attraction upon a unit mass, at the station is −0.0100+0.0001+0.0003= −0.0096 dyne. Similarly, if zone 17 is all upon the ocean, and the average depth of the water is 2710 fathoms (or 100 of the specified units of depth) the correction as read from the map is +0.0100 dyne, the correction for departure from proportionality is +0.0001, and if the station is at the elevation of 5000 feet the correction for elevation is −0.0001 and the total effect of the topography in this zone and its isostatic compensation is +0.0100+0.0001−0.0001=0.0100 dyne.

The unit of elevation for zones 13 to 7 is 1000 feet, and for zones 6 to 1 is 10 000 feet. These large units of elevation make it easy to estimate quickly the mean elevation within each compartment with the required degree of accuracy.

Note that for zones 13–1 there are no corrections for elevation of station and for departure from proportionality.

The reduction tables thus far described are believed to cover all cases which will arise when the gravity station is on land. But in order to provide for the computation of the effects of topography and isostatic compensation on the attraction at a gravity station on a vessel at sea, such as those occupied by Dr. Hecker on the Atlantic and Pacific Oceans, the two supplementary tables for use in connection with gravity stations at sea were prepared. These tables are computed on the supposition that the observation station is at sea level, since the correction for the small elevation above sea level to which the station is limited on board a ship would be less than 0.0001 dyne in every case. But one correction is to be taken out from these tables for each compartment. This correction is to be taken from the first table if that can be done without using any of the values marked with an asterisk. Otherwise it is to be taken from the second table in order to avoid large errors of interpolation which otherwise would occur on account of the large second differences in the first table.

For the remaining zones 18 to 1 no such sea tables are necessary, as the regular tables prepared for land stations cover all cases which will arise.

REDUCTION TABLES FOR LETTERED ZONES.

Zone A.

[Inner radius, zero; outer radius, 2 meters. One compartment.]

[illegible]

Elevation of station and compartment	Correction for—		
	Topography	Compensation	Topography and compensation
Feet			
0	0	0	0
5	+1	0	+1
10	+2	0	+2
100	+2	0	+2
1 000	+2	0	+2
2 000	+2	0	+2
3 000	+2	0	+2
4 000	+2	0	+2
5 000	+2	0	+2
6 000	+2	0	+2
7 000	+2	0	+2
8 000	+2	0	+2
9 000	+2	0	+2
10 000	+2	0	+2
11 000	+2	0	+2
12 000	+2	0	+2
13 000	+2	0	+2
14 000	+2	0	+2
15 000	+2	0	+2

For zone A the correction to gravity is a function only of the elevation of the station, for all land stations, as shown by the above table.

Zone B.

[Inner radius, 2 meters; outer radius, 68 meters. Four compartments.]

Mean elevation of compartment	Correction for—			Correction for elevation of station—									
				Above compartment					Below compartment				
	Topography	Compensation	Topography and compensation	25 feet	50 feet	75 feet	100 feet	125 feet	25 feet	50 feet	75 feet	100 feet	125 feet
Feet													
0	0	0	0	0	0	0	0	0					
10	0	0	0	0	0	0	0	0					
20	+ 1	0	+ 1	0	0	0	0	0					
30	+ 2	0	+ 2	0	0	−1	−1	−1	−3				
40	+ 3	0	+ 3	0	0	−1	−1	−1	−3				
50	+ 3	0	+ 3	0	−1	−1	−1	−2	−3	−6			
60	+ 4	0	+ 4	0	−1	−1	−1	−2	−3	−6			
70	+ 4	0	+ 4	0	−1	−1	−2	−2	−3	−6			
80	+ 5	0	+ 5	0	−1	−1	−2	−2	−3	−6	−9		
90	+ 5	0	+ 5	−1	−1	−2	−2	−3	−3	−6	−9		
100	+ 6	0	+ 6	−1	−1	−2	−2	−3	−3	−6	−9	−12	
150	+ 8	0	+ 8	−1	−2	−2	−3	−4	−2	−5	−8	−11	−14
200	+10	0	+10	−1	−2	−3	−4	−5	−2	−5	−7	−10	−12
300	+12	0	+12	−1	−2	−4	−5	−6	−2	−4	−6	− 8	−10
400	+14	0	+14	−1	−3	−4	−5	−6	−2	−4	−6	− 8	− 9
500	+14	0	+14	−1	−3	−4	−5	−7	−2	−3	−5	− 7	− 8
1 000	+16	0	+16	−2	−3	−5	−6	−7	−2	−3	−5	− 6	− 7
2 000	+17	0	+17	−2	−3	−5	−6	−7	−2	−3	−5	− 6	− 7
3 000	+17	0	+17	−2	−3	−5	−6	−7	−2	−3	−5	− 6	− 7
4 000	+17	0	+17	−2	−3	−5	−6	−7	−2	−3	−5	− 6	− 7
5 000	+17	0	+17	−2	−3	−5	−6	−7	−2	−3	−5	− 6	− 7
6 000	+17	0	+17	−2	−3	−5	−6	−7	−2	−3	−5	− 6	− 7
7 000	+17	0	+17	−2	−3	−5	−6	−7	−2	−3	−5	− 6	− 7
8 000	+17	0	+17	−2	−3	−5	−6	−7	−2	−3	−5	− 6	− 7
9 000	+18	−1	+17	−2	−3	−5	−6	−7	−2	−3	−5	− 6	− 7
10 000	+18	−1	+17	−2	−3	−5	−6	−7	−2	−3	−5	− 6	− 7
15 000	+19	−1	+18	−2	−3	−5	−6	−7	−2	−3	−5	− 6	− 7

It is assumed that the mean elevation for any compartment in this zone will never be negative (below sea level) for any gravity station on land.

Zone C.

[Inner radius, 68 meters; outer radius, 230 meters. Four compartments.]

Mean elevation of compartment	Correction for—			Correction for elevation of station—																			
				Above compartment										Below compartment									
	Topography	Compensation	Topography and compensation	50 feet	100 feet	150 feet	200 feet	250 feet	300 feet	350 feet	400 feet	450 feet	500 feet	50 feet	100 feet	150 feet	200 feet	250 feet	300 feet	350 feet	400 feet	450 feet	500 feet
Fathoms																							
− 80	− 9	0	− 9																				
− 40	− 4	0	− 4	0	0	0	0																
Feet																							
0	0	0	0	0	0	0	0	0	0	0	0	0	0										
100	+ 1	0	+ 1	0	0	0	0	0	0	0	0	0	− 1	−1	−2								
150	+ 2	0	+ 2	0	0	0	0	0	0	0	0	− 1	− 1	−1	−3	−4							
200	+ 4	0	+ 4	0	0	0	0	0	0	0	− 1	− 1	− 1	−2	−4	−6	− 8						
250	+ 6	0	+ 6	0	0	0	0	0	0	0	− 1	− 1	− 2	−2	−4	−7	−10	−12					
300	+ 8	0	+ 8	0	0	0	0	0	0	0	− 1	− 1	− 2	−2	−5	−8	−11	−14	−16				
350	+10	0	+10	0	0	0	0	0	0	−1	− 1	− 2	− 2	−2	−5	−8	−12	−15	−18	−20			
400	+12	0	+12	0	0	0	0	0	0	−1	− 2	− 2	− 3	−2	−5	−8	−12	−16	−19	−21	−24		
450	+13	0	+13	0	0	0	0	0	0	−1	− 2	− 2	− 3	−2	−4	−7	−11	−15	−19	−22	−25	−26	
500	+15	0	+15	0	0	0	0	0	0	−1	− 2	− 3	− 4	−2	−4	−7	−11	−15	−19	−23	−26	−28	−30
550	+16	0	+16	0	0	0	0	0	0	−1	− 2	− 3	− 4	−2	−4	−6	−10	−14	−18	−22	−26	−28	−31
600	+18	0	+18	0	0	0	0	0	−1	−2	− 3	− 4	− 5	−2	−4	−6	−10	−14	−18	−22	−26	−29	−32
700	+20	0	+20	0	0	0	−1	−1	−2	−3	− 4	− 5	− 6	−1	−3	−6	− 9	−13	−17	−20	−24	−28	−31
800	+22	0	+22	0	−1	−1	−2	−2	−3	−4	− 5	− 6	− 7	−1	−3	−5	− 9	−12	−16	−19	−22	−26	−29
900	+24	0	+24	0	−1	−2	−2	−2	−4	−5	− 6	− 7	− 8	−1	−3	−5	− 8	−11	−15	−18	−21	−24	−27
1 000	+26	0	+26	0	−1	−2	−2	−3	−4	−6	− 7	− 8	− 9	−1	−3	−5	− 8	−11	−14	−17	−20	−23	−26
1 200	+28	0	+28	−1	−2	−2	−3	−4	−5	−6	− 7	− 9	−11	0	−2	−4	− 7	−10	−13	−15	−18	−20	−23
1 400	+30	0	+30	−1	−2	−2	−3	−4	−5	−6	− 8	− 9	−11	0	−2	−4	− 6	− 9	−11	−14	−16	−18	−21
1 600	+32	0	+32	−1	−2	−3	−3	−4	−6	−7	− 9	−10	−12	0	−2	−4	− 6	− 8	−10	−13	−15	−17	−20
2 000	+34	0	+34	−1	−2	−3	−4	−5	−6	−8	−10	−11	−13	0	−1	−3	− 5	− 7	−10	−12	−14	−16	−18
2 500	+36	0	+36	−1	−2	−3	−4	−5	−7	−8	−10	−11	−13	0	−1	−3	− 5	− 7	− 9	−12	−13	−15	−17
3 000	+38	0	+38	−1	−2	−3	−4	−6	−7	−9	−10	−12	−14	0	−1	−3	− 5	− 7	− 9	−12	−14	−15	−16
5 000	+41	−1	+40	−1	−2	−3	−4	−6	−7	−9	−10	−12	−14	0	−1	−2	− 4	− 6	− 8	−10	−12	−14	−15
15 000	+44	−2	+42	−1	−2	−3	−4	−6	−7	−9	−11	−12	−14	0	−1	−2	− 4	− 6	− 8	−10	−12	−13	−15

Zone D.

[Inner radius, 230 meters; outer radius, 590 meters. Six compartments.]

Mean elevation of compartment	Correction for—			Correction for elevation of station—																											
				Above compartment														Below compartment													
	Topography	Compensation	Topography and compensation	100 feet	200 feet	300 feet	400 feet	500 feet	600 feet	700 feet	800 feet	900 feet	1000 feet	1100 feet	1200 feet	1300 feet	1400 feet	100 feet	200 feet	300 feet	400 feet	500 feet	600 feet	700 feet	800 feet	900 feet	1000 feet	1100 feet	1200 feet	1300 feet	1400 feet
Fathoms																															
−200	−11	0	−11	−1	−2	−2	−2																								
−150	− 7	0	− 7	−1	−2	−2	−2	−2	−2	−2																					
−100	− 4	0	− 4	−1	−2	−2	−2	−2	−2	−2	−2	−2	−2																		
− 50	− 1	0	− 1	−1	−1	−2	−2	−2	−2	−2	−2	−2	−2	−2	−2	−2	−2														
Feet																															
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0														
300	+ 2	0	+ 2	+1	+2	+3	+3	+3	+4	+4	+ 3	+ 3	+ 3	+ 3	+ 3	+ 3	+ 3	−2	−3	−4											
350	+ 3	0	+ 3	+1	+2	+3	+4	+4	+4	+4	+ 4	+ 4	+ 4	+ 3	+ 3	+ 3	+ 3	−2	−3	−5											
400	+ 3	0	+ 3	+1	+2	+3	+4	+4	+4	+4	+ 4	+ 4	+ 4	+ 3	+ 3	+ 3	+ 3	−2	−3	−5	− 6										
450	+ 4	0	+ 4	+1	+3	+3	+4	+4	+4	+4	+ 4	+ 4	+ 4	+ 3	+ 3	+ 3	+ 3	−2	−3	−5	− 7										
500	+ 5	0	+ 5	+1	+3	+4	+4	+4	+4	+5	+ 4	+ 4	+ 4	+ 3	+ 3	+ 3	+ 2	−3	−4	−6	− 8	−10									
550	+ 6	0	+ 6	+1	+3	+4	+4	+4	+4	+5	+ 4	+ 4	+ 4	+ 3	+ 3	+ 3	+ 2	−3	−4	−6	− 9	−11									
600	+ 7	0	+ 7	+1	+3	+4	+4	+4	+4	+5	+ 4	+ 4	+ 4	+ 3	+ 3	+ 3	+ 2	−3	−5	−7	− 9	−11	−14								
650	+ 8	0	+ 8	+1	+3	+4	+4	+4	+4	+5	+ 4	+ 4	+ 4	+ 3	+ 3	+ 2	+ 2	−3	−5	−7	− 9	−12	−15								
700	+ 8	0	+ 8	+1	+3	+4	+4	+4	+4	+4	+ 4	+ 4	+ 3	+ 3	+ 3	+ 2	+ 2	−3	−5	−7	− 9	−12	−15	−16							
750	+ 9	0	+ 9	+1	+3	+4	+4	+4	+4	+4	+ 4	+ 4	+ 3	+ 3	+ 2	+ 2	+ 1	−3	−5	−7	− 9	−12	−15	−17							
800	+10	0	+10	+1	+3	+4	+4	+4	+4	+4	+ 4	+ 3	+ 3	+ 2	+ 2	+ 1	+ 1	−3	−5	−7	−10	−13	−16	−18	−20						
850	+11	0	+11	+1	+3	+4	+4	+4	+4	+4	+ 4	+ 3	+ 2	+ 2	+ 1	+ 1	0	−3	−5	−7	−10	−13	−16	−18	−21						
900	+12	0	+12	+1	+3	+4	+4	+4	+4	+4	+ 3	+ 3	+ 2	+ 2	+ 1	0	0	−3	−5	−7	−10	−14	−17	−19	−21	−24					
950	+13	0	+13	+1	+3	+4	+4	+4	+4	+4	+ 3	+ 2	+ 2	+ 1	+ 1	0	− 1	−3	−5	−7	−10	−14	−17	−19	−22	−25					
1 000	+14	0	+14	+1	+3	+4	+4	+4	+4	+3	+ 3	+ 2	+ 1	+ 1	0	0	− 1	−3	−5	−8	−11	−14	−18	−20	−23	−25	−28				
1 050	+15	0	+15	+1	+3	+3	+4	+4	+3	+3	+ 3	+ 2	+ 1	0	0	− 1	− 2	−3	−5	−8	−11	−14	−18	−20	−23	−26	−29				
1 100	+16	0	+16	+1	+3	+3	+4	+4	+3	+3	+ 3	+ 2	+ 1	0	− 1	− 1	− 2	−3	−5	−8	−11	−14	−18	−21	−24	−27	−29	−32			
1 150	+17	0	+17	+1	+3	+3	+4	+3	+3	+3	+ 2	+ 1	0	0	− 1	− 2	− 3	−3	−5	−8	−11	−14	−18	−21	−24	−27	−30	−33			
1 200	+18	0	+18	+1	+3	+3	+3	+3	+3	+2	+ 2	+ 1	0	− 1	− 2	− 2	− 3	−3	−5	−8	−11	−15	−18	−21	−25	−28	−31	−33	−36		
1 250	+19	0	+19	+1	+3	+3	+3	+3	+2	+2	+ 1	0	0	− 1	− 2	− 3	− 4	−3	−5	−8	−11	−15	−18	−21	−25	−28	−31	−34	−37		
1 300	+20	0	+20	+1	+3	+3	+3	+3	+2	+2	+ 1	0	− 1	− 1	− 2	− 3	− 4	−3	−5	−8	−11	−15	−19	−21	−25	−29	−32	−35	−37	−40	
1 400	+22	0	+22	+1	+3	+3	+3	+2	+2	+1	0	0	− 1	− 2	− 3	− 4	− 5	−3	−5	−8	−11	−15	−19	−21	−25	−29	−32	−36	−39	−41	−44
1 500	+23	0	+23	+1	+2	+3	+3	+2	+2	+1	0	− 1	− 2	− 3	− 4	− 5	− 6	−3	−5	−7	−10	−14	−18	−21	−25	−29	−32	−36	−39	−42	−44
1 600	+25	0	+25	+1	+2	+2	+2	+2	+1	0	0	− 1	− 2	− 3	− 4	− 5	− 7	−3	−5	−7	−10	−14	−18	−21	−25	−29	−32	−36	−40	−43	−46
1 700	+26	0	+26	+1	+2	+2	+2	+1	+1	0	− 1	− 2	− 3	− 4	− 5	− 6	− 7	−2	−4	−6	− 9	−13	−17	−20	−24	−28	−32	−35	−39	−43	−46
1 800	+28	0	+28	+1	+2	+2	+2	+1	0	0	− 2	− 3	− 4	− 5	− 6	− 7	− 8	−2	−4	−6	− 9	−13	−17	−20	−23	−28	−31	−35	−39	−43	−47
2 000	+30	0	+30	+1	+2	+1	+1	0	0	−1	− 2	− 4	− 5	− 6	− 7	− 8	− 9	−2	−4	−6	− 8	−12	−15	−18	−22	−26	−30	−34	−38	−42	−45
2 200	+32	0	+32	+1	+1	+1	+1	0	−1	−2	− 3	− 4	− 6	− 7	− 8	− 9	−10	−2	−4	−5	− 8	−11	−14	−17	−20	−24	−28	−32	−36	−40	−44
2 400	+34	0	+34	0	0	0	0	−1	−2	−3	− 4	− 5	− 6	− 8	− 9	−10	−11	−2	−4	−5	− 8	−10	−13	−16	−19	−23	−26	−30	−34	−38	−42
2 600	+36	0	+36	0	0	0	0	−1	−2	−3	− 4	− 6	− 7	− 8	−10	−11	−12	−2	−3	−5	− 7	−10	−13	−16	−18	−22	−25	−29	−32	−36	−40
2 800	+38	0	+38	0	0	0	−1	−2	−3	−4	− 5	− 6	− 8	− 9	−10	−11	−13	−2	−3	−5	− 7	−10	−13	−15	−18	−21	−24	−28	−31	−35	−38
3 000	+40	0	+40	0	0	0	−1	−2	−3	−4	− 5	− 7	− 8	− 9	−11	−12	−14	−2	−3	−5	− 7	−10	−13	−15	−18	−21	−24	−27	−30	−34	−37
3 200	+42	−1	+41	0	−1	−1	−1	−2	−3	−5	− 6	− 7	− 9	−10	−11	−12	−14	−1	−2	−4	− 6	− 9	−12	−14	−17	−20	−23	−26	−29	−32	−35
3 400	+43	−1	+42	0	−1	−1	−1	−3	−4	−5	− 6	− 8	− 9	−11	−12	−13	−15	−1	−2	−4	− 6	− 8	−11	−13	−16	−19	−22	−25	−28	−31	−34
3 600	+44	−1	+43	0	−1	−1	−2	−3	−4	−5	− 6	− 8	− 9	−11	−13	−14	−15	−1	−2	−4	− 6	− 8	−10	−12	−15	−18	−21	−24	−27	−30	−33
3 800	+45	−1	+44	0	−1	−1	−2	−3	−4	−5	− 7	− 8	−10	−11	−13	−14	−16	−1	−2	−4	− 5	− 7	−10	−12	−14	−17	−20	−23	−26	−29	−32
4 000	+46	−1	+45	0	−1	−1	−2	−3	−4	−5	− 7	− 8	−10	−12	−13	−15	−16	−1	−2	−3	− 5	− 7	−10	−12	−14	−17	−19	−22	−25	−28	−31
4 500	+48	−1	+47	0	−1	−1	−2	−3	−5	−6	− 8	− 9	−11	−12	−14	−16	−17	−1	−2	−3	− 5	− 7	−10	−11	−13	−16	−19	−21	−24	−26	−29
5 000	+50	−1	+49	0	−1	−2	−2	−4	−5	−6	− 8	−10	−12	−13	−15	−16	−18	−1	−2	−3	− 5	− 7	− 9	−11	−13	−16	−18	−20	−23	−25	−28
5 500	+51	−1	+50	−1	−1	−2	−2	−4	−5	−7	− 8	−10	−12	−14	−15	−17	−18	−1	−2	−3	− 5	− 6	− 8	−10	−12	−15	−17	−19	−22	−24	−27
6 000	+52	−1	+51	−1	−1	−2	−2	−4	−6	−7	− 9	−11	−13	−14	−16	−17	−19	−1	−2	−3	− 4	− 6	− 8	−10	−12	−14	−16	−18	−21	−23	−26
7 000	+54	−1	+53	−1	−1	−2	−2	−4	−6	−7	− 9	−11	−13	−14	−16	−18	−19	−1	−2	−3	− 4	− 6	− 8	−10	−12	−14	−16	−18	−20	−23	−25
8 000	+56	−1	+55	−1	−1	−2	−2	−4	−6	−7	− 9	−11	−13	−15	−16	−18	−19	−1	−2	−3	− 4	− 6	− 8	−10	−12	−14	−16	−18	−20	−22	−25
9 000	+58	−2	+56	−1	−1	−2	−2	−4	−6	−7	− 9	−11	−13	−15	−16	−18	−19	−1	−2	−2	− 3	− 5	− 8	− 9	−11	−13	−15	−17	−19	−21	−24
10 000	+58	−2	+56	−1	−1	−2	−3	−4	−6	−8	−10	−11	−13	−15	−16	−18	−20	−1	−1	−2	− 3	− 5	− 7	− 8	−10	−12	−14	−16	−18	−20	−22
15 000	+61	−3	+58	−1	−1	−2	−3	−5	−6	−8	−10	−12	−14	−15	−17	−19	−20	−1	−1	−2	− 3	− 5	− 7	− 8	−10	−12	−14	−16	−18	−20	−22

Zone E.

[Inner radius, 590 meters; outer radius, 1280 meters. Eight compartments.]

Mean elevation of compartment	Correction for—			Correction for elevation of station—																							
	Topography	Compensation	Topography and compensation	Above compartment												Below compartment											
				200 feet	400 feet	600 feet	800 feet	1000 feet	1200 feet	1400 feet	1600 feet	1800 feet	2000 feet	2500 feet	3000 feet	200 feet	400 feet	600 feet	800 feet	1000 feet	1200 feet	1400 feet	1600 feet	1800 feet	2000 feet	2500 feet	3000 feet
Fathoms																											
−500	−18	+1	−17	−1																							
−450	−16	+1	−15	−1	−2																						
−400	−13	0	−13	−1	−2	−3																					
−350	−11	0	−11	−1	−2	−3	−3	−4																			
−300	− 9	0	− 9	−1	−2	−3	−3	−4	−4	−4																	
−250	− 6	0	− 6	−1	−2	−3	−3	−4	−4	−4	− 4																
−200	− 4	0	− 4	−1	−2	−2	−3	−4	−4	−4	− 4	− 4	− 4														
−150	− 2	0	− 2	−1	−2	−2	−3	−4	−4	−4	− 4	− 4	− 4														
−100	− 1	0	− 1	−1	−1	−2	−2	−2	−3	−3	− 3	− 3	− 3	− 3													
− 50	− 1	0	− 1	0	−1	−1	−1	−1	−1	−1	− 2	− 2	− 2	− 2	− 1												
Feet																											
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0												
400	+ 1	0	+ 1	+1	+2	+2	+3	+3	+3	+3	+ 4	+ 4	+ 4	+ 4	+ 3	−1	−2										
600	+ 2	0	+ 2	+1	+2	+3	+3	+4	+5	+5	+ 5	+ 5	+ 5	+ 5	+ 4	−1	−2	− 4									
800	+ 3	0	+ 3	+1	+3	+4	+5	+6	+6	+6	+ 6	+ 6	+ 6	+ 5	+ 5	−1	−3	− 5	− 6								
1 000	+ 5	0	+ 5	+2	+3	+4	+5	+6	+6	+6	+ 6	+ 6	+ 6	+ 5	+ 5	−2	−4	− 6	− 8	−10							
1 200	+ 7	0	+ 7	+2	+4	+4	+5	+7	+7	+7	+ 7	+ 7	+ 7	+ 5	+ 4	−2	−5	− 7	− 9	−12	−14						
1 400	+ 9	0	+ 9	+2	+4	+4	+5	+7	+7	+7	+ 7	+ 7	+ 7	+ 5	+ 4	−2	−5	− 8	−10	−13	−16	−18					
1 600	+11	0	+11	+2	+4	+5	+5	+7	+7	+7	+ 7	+ 6	+ 6	+ 4	+ 3	−2	−5	− 8	−11	−14	−17	−20	−22				
1 800	+14	0	+14	+2	+4	+5	+5	+7	+6	+6	+ 6	+ 6	+ 6	+ 4	+ 2	−2	−5	− 9	−12	−16	−19	−22	−25	−28			
2 000	+17	−1	+16	+2	+4	+5	+5	+7	+6	+6	+ 6	+ 6	+ 5	+ 3	+ 1	−2	−6	− 9	−13	−16	−20	−23	−27	−30	−32		
2 200	+20	−1	+19	+2	+4	+5	+5	+6	+6	+5	+ 5	+ 5	+ 4	+ 2	0	−2	−6	−10	−13	−17	−21	−25	−28	−32	−34		
2 400	+22	−1	+21	+2	+4	+5	+5	+6	+6	+5	+ 5	+ 4	+ 4	+ 1	− 1	−2	−6	− 9	−13	−17	−21	−25	−29	−33	−36		
2 600	+24	−1	+23	+2	+4	+5	+5	+6	+3	+4	+ 4	+ 3	+ 3	0	− 2	−2	−6	− 9	−13	−17	−21	−25	−29	−34	−37	−45	
2 800	+27	−1	+26	+2	+3	+4	+4	+5	+5	+4	+ 3	+ 2	+ 2	0	− 3	−2	−5	− 9	−13	−17	−21	−26	−30	−34	−38	−47	
3 000	+29	−1	+28	+2	+3	+4	+4	+5	+4	+3	+ 3	+ 2	+ 1	− 1	− 4	−2	−5	− 9	−13	−17	−21	−26	−30	−35	−39	−49	−56
3 200	+31	−1	+30	+2	+3	+3	+4	+4	+4	+3	+ 2	+ 2	+ 1	− 2	− 5	−2	−5	− 9	−12	−16	−20	−25	−30	−35	−39	−50	−58
3 400	+33	−1	+32	+2	+3	+3	+4	+4	+3	+2	+ 2	+ 1	0	− 3	− 6	−2	−5	− 8	−12	−16	−20	−25	−29	−35	−39	−50	−59
3 600	+35	−1	+34	+1	+3	+3	+4	+4	+3	+2	+ 1	0	− 1	− 4	− 7	−2	−5	− 8	−12	−16	−20	−24	−29	−34	−39	−50	−60
3 800	+37	−1	+36	+1	+3	+3	+3	+3	+2	+1	0	0	− 1	− 4	− 8	−1	−5	− 8	−12	−15	−19	−24	−28	−33	−38	−50	−61
4 000	+38	−1	+37	+1	+3	+3	+3	+3	+2	+1	0	− 1	− 2	− 5	− 9	−1	−4	− 7	−11	−14	−19	−23	−28	−32	−37	−49	−60
4 200	+40	−1	+39	+1	+2	+2	+2	+2	+1	0	− 1	− 2	− 3	− 6	−10	−1	−4	− 7	−11	−14	−18	−22	−27	−32	−36	−48	−60
4 400	+42	−1	+41	+1	+2	+2	+2	+2	+1	0	− 1	− 2	− 3	− 7	−10	−1	−4	− 7	−10	−14	−18	−22	−27	−32	−36	−48	−60
4 600	+43	−1	+42	+1	+2	+2	+2	+2	0	−1	− 2	− 3	− 4	− 8	−11	−1	−4	− 7	−10	−13	−17	−21	−26	−31	−35	−47	−59
4 800	+45	−1	+44	+1	+2	+2	+1	+1	0	−1	− 2	− 3	− 5	− 8	−12	−1	−4	− 7	−10	−13	−17	−21	−26	−30	−34	−46	−58
5 000	+46	−1	+45	+1	+2	+2	+1	+1	0	−1	− 3	− 4	− 5	− 9	−13	−1	−4	− 6	−10	−13	−17	−20	−25	−29	−33	−45	−57
5 200	+48	−1	+47	+1	+2	+2	+1	+1	0	−2	− 3	− 4	− 6	−10	−13	−1	−4	− 6	− 9	−13	−16	−20	−24	−29	−33	−44	−56
5 400	+49	−1	+48	+1	+2	+2	+1	+1	−1	−2	− 3	− 4	− 6	−10	−14	−1	−3	− 6	− 9	−12	−16	−20	−24	−28	−32	−43	−55
5 600	+50	−1	+49	+1	+1	+1	0	0	−1	−3	− 4	− 5	− 7	−11	−15	−1	−3	− 6	− 9	−12	−16	−19	−23	−27	−31	−42	−54
5 800	+52	−2	+50	+1	+1	+1	0	0	−2	−3	− 4	− 6	− 7	−11	−15	−1	−3	− 5	− 8	−11	−15	−18	−22	−27	−30	−41	−52
6 000	+53	−2	+51	+1	+1	+1	0	0	−2	−3	− 5	− 6	− 8	−12	−16	−1	−3	− 5	− 8	−11	−14	−18	−22	−26	−30	−41	−51
6 200	+54	−2	+52	+1	+1	0	0	−1	−2	−3	− 5	− 6	− 8	−12	−16	−1	−3	− 5	− 8	−10	−14	−17	−21	−25	−29	−40	−50
6 400	+55	−2	+53	+1	+1	0	0	−1	−2	−4	− 5	− 7	− 8	−13	−17	−1	−3	− 5	− 8	−10	−13	−17	−21	−25	−28	−39	−49
6 600	+56	−2	+54	0	+1	0	0	−1	−2	−4	− 5	− 7	− 9	−13	−17	−1	−3	− 5	− 8	−10	−13	−16	−20	−24	−28	−38	−48
6 800	+57	−2	+55	0	+1	0	0	−1	−3	−4	− 6	− 7	− 9	−13	−18	−1	−3	− 5	− 7	−10	−13	−16	−20	−24	−27	−37	−47
7 000	+58	−2	+56	0	+1	0	0	−1	−3	−4	− 6	− 8	− 9	−14	−18	−1	−3	− 5	− 7	−10	−13	−16	−19	−23	−27	−37	−47
7 500	+60	−2	+58	0	+1	0	−1	−2	−3	−5	− 6	− 8	−10	−14	−19	0	−2	− 4	− 7	− 9	−12	−15	−19	−22	−26	−36	−45
8 000	+62	−2	+60	0	0	−1	−1	−2	−4	−5	− 7	− 9	−11	−15	−20	0	−2	− 4	− 6	− 9	−12	−15	−18	−22	−25	−34	−43
8 500	+64	−2	+62	0	0	−1	−1	−2	−4	−6	− 7	− 9	−11	−16	−20	0	−2	− 4	− 6	− 9	−12	−15	−18	−21	−24	−33	−42
9 000	+65	−2	+63	0	0	−1	−2	−3	−4	−6	− 8	− 9	−11	−16	−21	0	−2	− 4	− 6	− 8	−11	−14	−17	−20	−23	−32	−40
10 000	+69	−3	+66	0	0	−1	−2	−3	−4	−6	− 8	−10	−12	−17	−22	0	−2	− 4	− 6	− 8	−10	−13	−16	−19	−22	−30	−38
11 000	+71	−3	+68	0	0	−1	−2	−3	−5	−7	− 9	−10	−12	−17	−22	0	−2	− 3	− 5	− 7	−10	−12	−15	−18	−21	−28	−36
12 000	+72	−3	+69	0	0	−1	−2	−3	−5	−7	− 9	−11	−13	−18	−23	0	−2	− 3	− 5	− 6	− 9	−11	−14	−17	−20	−27	−34
13 000	+74	−3	+71	0	0	−1	−3	−4	−6	−8	− 9	−11	−13	−18	−23	0	−1	− 3	− 4	− 6	− 9	−11	−14	−17	−19	−26	−33
14 000	+76	−4	+72	0	0	−1	−3	−4	−6	−8	−10	−12	−14	−19	−24	0	−1	− 3	− 4	− 6	− 8	−11	−14	−17	−19	−25	−32
15 000	+77	−4	+73	0	0	−1	−3	−4	−6	−8	−10	−12	−14	−19	−24	0	−1	− 3	− 4	− 6	− 8	−10	−13	−16	−18	−25	−32

Zone F.

[Inner radius, 1280 meters; outer radius, 2290 meters. Ten compartments.]

Mean elevation of compartment	Correction for—			Correction for elevation of station—																							
				Above compartment												Below compartment											
	Topography	Compensation	Topography and compensation	250 feet	500 feet	750 feet	1000 feet	1250 feet	1500 feet	1750 feet	2000 feet	2250 feet	2500 feet	2750 feet	3000 feet	250 feet	500 feet	750 feet	1000 feet	1250 feet	1500 feet	1750 feet	2000 feet	2250 feet	2500 feet	2750 feet	3000 feet
Fathoms																											
-500	-8	+1	-7	-1																							
-450	-7	+1	-6	-1	-2																						
-400	-6	+1	-5	-1	-2	-2																					
-350	-4	0	-4	-1	-2	-2	-3																				
-300	-3	0	-3	-1	-2	-2	-3	-4																			
-250	-2	0	-2	-1	-1	-2	-2	-3	-4	-4																	
-200	-1	0	-1	-1	-1	-1	-2	-2	-3	-3	-3																
-150	-1	0	-1	-1	-1	-1	-1	-2	-2	-2	-2	-2															
-100	0	0	0	0	-1	-1	-1	-2	-2	-2	-2	-2	-2														
-50	0	0	0	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-2												
Feet																											
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0												
400	0	0	0	0	+1	+1	+1	+2	+2	+2	+2	+2	+2	+2	+3	0											
800	+1	0	+1	+1	+1	+2	+2	+3	+3	+3	+4	+4	+4	+4	+5	0	-1	-2									
1 200	+2	0	+2	+1	+2	+2	+3	+4	+5	+5	+5	+5	+6	+6	+6	-1	-2	-3	-4								
1 600	+4	0	+4	+1	+2	+3	+4	+5	+6	+6	+6	+7	+7	+7	+8	-1	-2	-4	-5	-6	-8						
2 000	+7	-1	+6	+1	+3	+4	+5	+6	+7	+7	+7	+7	+8	+8	+8	-1	-3	-5	-6	-8	-10	-12	-13				
2 200	+8	-1	+7	+1	+3	+4	+5	+6	+7	+7	+7	+8	+8	+8	+9	-1	-3	-5	-7	-8	-10	-12	-14				
2 400	+9	-1	+8	+2	+3	+4	+5	+6	+7	+7	+8	+8	+8	+8	+9	-1	-3	-5	-7	-8	-11	-13	-15	-16			
2 600	+11	-1	+10	+2	+3	+4	+5	+6	+7	+8	+8	+8	+8	+8	+9	-1	-3	-5	-7	-9	-12	-14	-16	-18	-21		
2 800	+12	-1	+11	+2	+3	+4	+5	+6	+7	+8	+8	+8	+8	+8	+9	-1	-3	-6	-8	-9	-12	-14	-17	-19	-22	-24	
3 000	+13	-1	+12	+2	+3	+4	+5	+6	+7	+8	+8	+8	+8	+8	+9	-1	-3	-6	-8	-10	-12	-15	-18	-20	-23	-25	-26
3 200	+15	-1	+14	+2	+3	+4	+5	+6	+7	+8	+8	+8	+8	+8	+9	-1	-3	-7	-8	-10	-13	-16	-19	-21	-24	-26	-28
3 400	+16	-1	+15	+2	+3	+4	+5	+6	+7	+8	+8	+8	+8	+8	+9	-1	-3	-6	-8	-11	-13	-16	-19	-22	-25	-27	-29
3 600	+17	-1	+16	+2	+3	+4	+5	+6	+7	+8	+8	+8	+8	+8	+8	-1	-3	-6	-8	-11	-14	-16	-19	-23	-26	-28	-30
3 800	+19	-1	+18	+2	+3	+4	+5	+6	+7	+7	+8	+8	+8	+8	+8	-2	-3	-6	-9	-11	-14	-17	-20	-23	-27	-29	-31
4 000	+20	-1	+19	+2	+3	+4	+5	+6	+7	+7	+7	+7	+8	+8	+8	-2	-3	-6	-9	-12	-14	-17	-20	-23	-27	-30	-32
4 200	+22	-1	+21	+2	+3	+4	+5	+6	+7	+7	+7	+7	+7	+7	+7	-2	-3	-6	-9	-12	-15	-18	-21	-24	-27	-30	-33
4 400	+23	-1	+22	+2	+3	+4	+5	+6	+7	+7	+7	+7	+7	+7	+7	-2	-3	-6	-9	-12	-15	-18	-21	-24	-27	-30	-33
4 600	+25	-1	+24	+2	+3	+4	+5	+6	+7	+7	+7	+7	+7	+7	+7	-2	-3	-6	-9	-12	-15	-18	-21	-24	-28	-31	-34
4 800	+26	-1	+25	+1	+3	+4	+5	+6	+7	+7	+7	+6	+6	+6	+6	-2	-3	-6	-9	-12	-15	-18	-21	-24	-27	-31	-34
5 000	+28	-2	+26	+1	+3	+4	+5	+6	+6	+6	+6	+6	+6	+6	+6	-2	-3	-6	-9	-12	-15	-18	-21	-24	-27	-31	-34
5 200	+30	-2	+28	+1	+3	+4	+4	+5	+6	+6	+6	+6	+6	+6	+6	-2	-3	-6	-9	-12	-15	-18	-21	-24	-27	-31	-35
5 400	+31	-2	+29	+1	+3	+4	+4	+5	+6	+6	+6	+6	+5	+5	+5	-2	-3	-6	-9	-12	-16	-18	-21	-24	-27	-31	-35
5 600	+32	-2	+30	+1	+3	+4	+4	+5	+6	+6	+5	+5	+5	+5	+5	-1	-3	-6	-9	-12	-15	-18	-21	-24	-27	-31	-35
5 800	+34	-2	+32	+1	+3	+3	+4	+5	+6	+6	+5	+5	+5	+4	+4	-1	-3	-6	-9	-12	-15	-18	-21	-24	-27	-31	-35
6 000	+35	-2	+33	+1	+3	+3	+4	+5	+5	+5	+5	+5	+4	+4	+4	-1	-3	-6	-9	-12	-15	-18	-21	-24	-27	-31	-35
6 200	+36	-2	+34	+1	+3	+3	+4	+5	+5	+5	+4	+4	+4	+4	+3	-1	-3	-6	-9	-12	-15	-18	-21	-24	-27	-31	-35
6 400	+38	-2	+36	+1	+3	+3	+4	+5	+5	+5	+4	+4	+4	+4	+3	-1	-3	-6	-9	-12	-15	-18	-21	-24	-27	-31	-35
6 600	+39	-2	+37	+1	+3	+3	+4	+5	+5	+4	+4	+4	+3	+3	+3	-1	-3	-6	-9	-12	-15	-18	-20	-24	-27	-31	-35
6 800	+40	-2	+38	+1	+2	+3	+4	+4	+5	+4	+4	+4	+3	+2	+2	-1	-3	-6	-8	-12	-15	-17	-20	-23	-26	-31	-34
7 000	+41	-2	+39	+1	+2	+3	+3	+4	+4	+4	+4	+3	+2	+2	+2	-1	-3	-5	-8	-11	-14	-17	-20	-23	-26	-30	-34
7 400	+43	-2	+41	+1	+2	+2	+3	+4	+4	+4	+3	+2	+2	+2	+1	-1	-3	-5	-7	-11	-14	-17	-19	-22	-25	-29	-33
7 800	+45	-2	+43	+1	+2	+2	+3	+3	+4	+3	+3	+2	+2	+1	+1	-1	-2	-5	-7	-10	-13	-16	-18	-22	-25	-29	-32
8 200	+47	-2	+45	+1	+2	+2	+3	+3	+3	+3	+2	+2	+2	+1	0	-1	-2	-5	-7	-10	-13	-16	-18	-21	-24	-28	-31
8 600	+50	-3	+47	+1	+2	+2	+3	+3	+3	+2	+2	+2	+1	+1	0	-1	-2	-4	-7	-10	-13	-15	-17	-21	-24	-28	-31
9 000	+52	-3	+49	+1	+2	+2	+2	+2	+3	+2	+2	+1	0	0	-1	-1	-2	-4	-7	-10	-13	-15	-17	-20	-24	-27	-30
9 500	+55	-3	+52	+1	+2	+2	+2	+2	+3	+2	+1	+1	0	-1	-1	-1	-2	-4	-7	-10	-13	-15	-17	-20	-24	-27	-30
10 000	+57	-3	+54	+1	+2	+2	+2	+2	+2	+2	+1	0	-1	-2	-2	-1	-2	-4	-6	-9	-12	-14	-17	-20	-23	-26	-29
10 500	+58	-3	+55	+1	+2	+2	+2	+2	+2	+2	+1	0	-1	-2	-2	-1	-2	-4	-5	-8	-11	-13	-16	-19	-22	-25	-28
11 000	+60	-3	+57	+1	+2	+2	+2	+2	+2	+1	0	-1	-2	-2	-3	-1	-2	-4	-5	-8	-10	-12	-15	-18	-22	-24	-27
11 500	+62	-3	+59	+1	+1	+1	+2	+2	+2	+1	0	-1	-2	-2	-3	-1	-2	-4	-5	-7	-10	-12	-14	-17	-21	-23	-26
12 000	+64	-4	+60	+1	+1	+1	+1	+1	+1	0	0	-1	-2	-3	-4	-1	-2	-3	-5	-7	-10	-12	-13	-16	-19	-22	-24
13 000	+67	-4	+63	+1	+1	+1	+1	+1	+1	0	-1	-2	-3	-4	-5	-1	-2	-3	-5	-7	-9	-11	-13	-16	-18	-20	-23
14 000	+69	-4	+65	0	+1	+1	+1	0	0	-1	-2	-3	-4	-5	-6	-1	-2	-3	-5	-6	-8	-11	-13	-15	-17	-19	-21
15 000	+72	-4	+68	0	+1	+1	+1	0	0	-1	-2	-4	-5	-6	-7	-1	-2	-3	-5	-6	-8	-11	-13	-15	-17	-19	-21

Zone G.

[Inner radius, 2290 meters; outer radius, 3520 meters. Twelve compartments.]

Mean elevation of compartment	Correction for—			Correction for elevation of station—																				
	Topography	Compensation	Topography and compensation	Above compartment									Below compartment											
				500 feet	1000 feet	1500 feet	2000 feet	2500 feet	3000 feet	3500 feet	4000 feet	4500 feet	400 feet	800 feet	1200 feet	1600 feet	2000 feet	2400 feet	2800 feet	3200 feet	3600 feet	4000 feet	4400 feet	4800 feet
Fathoms																								
−800	− 8	+1	− 7	−1																				
−750	− 7	+1	− 6	−1																				
−700	− 7	+1	− 6	−1																				
−650	− 6	+1	− 5	−1	−2																			
−600	− 5	+1	− 4	−1	−2																			
−550	− 5	+1	− 4	−1	−2	−3																		
−500	− 4	+1	− 3	−1	−2	−2																		
−450	− 3	+1	− 2	−1	−1	−2	−3	−3																
−400	− 2	0	− 2	−1	−1	−2	−2	−3																
−350	− 1	0	− 1	−1	−1	−2	−2	−3																
−300	− 1	0	− 1	−1	−1	−2	−2	−3	−3															
−250	− 1	0	− 1	−1	−1	−2	−2	−2	−2															
−200	0	0	0	−1	−1	−1	−1	−2	−2	−2														
−150	0	0	0	−1	−1	−1	−1	−2	−2	−2	−2													
−100	0	0	0	0	0	−1	−1	−1	−1	−1	−1													
− 50	0	0	0	0	0	0	0	−1	−1	−1	−1	−1												
Feet																								
0	0	0	0	0	0	0	0	0	0	0	0	0												
500	0	0	0	0	0	+1	+1	+2	+2	+2	+2	+2	0											
1 000	0	0	0	+1	+1	+2	+2	+3	+3	+3	+4	+4	0	0										
1 500	+ 1	0	+ 1	+1	+2	+3	+3	+4	+4	+4	+5	+5	−1	−1	−1									
2 000	+ 3	−1	+ 2	+1	+2	+3	+4	+5	+6	+6	+7	+7	−1	−2	−3	−4	− 5							
2 500	+ 4	−1	+ 3	+1	+2	+4	+4	+5	+6	+7	+7	+8	−1	−2	−3	−5	− 6	−7						
3 000	+ 6	−1	+ 5	+2	+3	+4	+5	+6	+7	+7	+8	+8	−1	−2	−4	−6	− 7	−8	−10					
3 500	+ 7	−1	+ 6	+2	+3	+5	+6	+7	+8	+8	+9	+9	−1	−2	−4	−6	− 8	−9	−11	−12				
4 000	+ 9	−1	+ 8	+2	+3	+5	+6	+7	+8	+8	+9	+9	−2	−3	−5	−7	− 9	−11	−12	−14	−15	−17		
4 500	+11	−1	+10	+2	+3	+5	+6	+7	+8	+8	+9	+9	−2	−3	−5	−7	−10	−12	−13	−15	−17	−19	−22	
5 000	+14	−2	+12	+2	+4	+5	+6	+7	+8	+8	+9	+9	−2	−4	−6	−8	−10	−12	−14	−16	−18	−21	−23	−25
5 200	+15	−2	+13	+2	+4	+5	+6	+7	+8	+8	+9	+9	−2	−4	−6	−9	−11	−13	−15	−17	−19	−22	−24	−26
5 400	+16	−2	+14	+2	+4	+5	+6	+7	+8	+8	+9	+9	−2	−4	−6	−9	−11	−14	−16	−18	−20	−22	−24	−27
5 600	+17	−2	+15	+2	+4	+5	+6	+7	+8	+8	+9	+9	−2	−4	−6	−9	−11	−14	−16	−18	−20	−22	−25	−28
5 800	+17	−2	+15	+2	+4	+5	+6	+7	+8	+8	+9	+9	−2	−4	−6	−9	−11	−14	−16	−18	−20	−22	−25	−28
6 000	+18	−2	+16	+2	+4	+5	+6	+7	+8	+8	+9	+9	−2	−4	−6	−9	−11	−14	−16	−18	−21	−23	−26	−29
6 200	+19	−2	+17	+2	+4	+5	+6	+7	+8	+8	+9	+9	−2	−4	−6	−9	−12	−14	−16	−18	−21	−24	−26	−29
6 400	+20	−2	+18	+2	+4	+5	+6	+7	+8	+8	+9	+9	−2	−4	−6	−9	−12	−14	−16	−19	−22	−25	−27	−30
6 600	+21	−2	+19	+2	+4	+5	+6	+7	+8	+8	+8	+8	−2	−4	−6	−9	−12	−14	−17	−19	−23	−26	−28	−31
6 800	+22	−2	+20	+2	+4	+5	+6	+7	+8	+8	+8	+8	−2	−4	−6	−9	−12	−14	−17	−20	−23	−26	−29	−32
7 000	+23	−2	+21	+2	+4	+5	+6	+7	+8	+8	+8	+8	−2	−4	−6	−9	−12	−15	−17	−20	−23	−26	−29	−32
7 400	+24	−2	+22	+2	+4	+5	+6	+7	+8	+8	+8	+8	−2	−4	−6	−9	−12	−14	−17	−20	−23	−26	−30	−33
7 800	+26	−2	+24	+2	+4	+5	+6	+6	+7	+7	+7	+7	−2	−4	−6	−9	−12	−14	−17	−20	−23	−27	−30	−33
8 200	+28	−2	+26	+2	+3	+5	+6	+6	+7	+7	+7	+7	−2	−4	−6	−9	−11	−14	−17	−20	−24	−27	−30	−34
8 600	+30	−3	+27	+2	+3	+5	+6	+6	+7	+7	+7	+7	−2	−4	−6	−9	−11	−14	−17	−20	−24	−27	−30	−34
9 000	+32	−3	+29	+2	+3	+5	+6	+6	+7	+7	+6	+6	−2	−4	−6	−9	−11	−14	−17	−20	−24	−27	−31	−34
9 500	+34	−3	+31	+2	+3	+5	+6	+6	+6	+6	+6	+6	−2	−4	−6	−9	−11	−14	−17	−20	−23	−27	−31	−34
10 000	+36	−3	+33	+2	+3	+5	+5	+6	+6	+6	+5	+5	−2	−4	−6	−9	−11	−14	−16	−19	−23	−27	−31	−34
10 500	+38	−3	+35	+2	+3	+4	+5	+5	+6	+6	+5	+5	−2	−4	−6	−8	−10	−13	−16	−19	−23	−27	−30	−34
11 000	+40	−3	+37	+2	+3	+4	+4	+5	+5	+5	+4	+4	−2	−4	−6	−8	−10	−13	−16	−19	−23	−26	−30	−33
11 500	+41	−3	+38	+2	+3	+4	+4	+5	+5	+5	+4	+4	−2	−4	−6	−7	−10	−13	−15	−18	−22	−26	−29	−32
12 000	+44	−4	+40	+2	+3	+4	+4	+4	+4	+4	+3	+3	−2	−3	−5	−7	−10	−13	−15	−18	−21	−25	−29	−32
12 500	+46	−4	+42	+2	+3	+4	+4	+4	+4	+4	+3	+3	−2	−3	−5	−7	−10	−12	−15	−17	−21	−25	−28	−32
13 000	+47	−4	+43	+2	+3	+3	+3	+4	+4	+3	+3	+2	−2	−3	−5	−7	−10	−12	−14	−16	−20	−24	−28	−32
13 500	+49	−4	+45	+2	+3	+3	+3	+4	+4	+3	+3	+2	−2	−3	−5	−7	− 9	−12	−14	−16	−20	−24	−28	−32
14 000	+50	−4	+46	+1	+2	+3	+3	+3	+3	+2	+2	+1	−1	−3	−5	−7	− 9	−12	−14	−16	−20	−23	−27	−31
14 500	+52	−4	+48	+1	+2	+3	+3	+3	+3	+2	+2	+1	−1	−3	−5	−7	− 9	−11	−13	−16	−19	−23	−26	−30
15 000	+54	−5	+49	+1	+2	+3	+3	+3	+2	+1	+1	0	−1	−3	−5	−7	− 7	−11	−13	−16	−19	−22	−26	−29

Zone H.

[Inner radius, 3520 meters; outer radius, 5240 meters. Sixteen compartments.]

Mean elevation of compartment	Correction for—			Correction for elevation of station —																							
	Topography	Compensation	Topography and compensation	Above compartment												Below compartment											
				600 feet	1200 feet	1800 feet	2400 feet	3000 feet	3600 feet	4200 feet	4800 feet	5400 feet	6000 feet	6600 feet	7200 feet	600 feet	1200 feet	1800 feet	2400 feet	3000 feet	3600 feet	4200 feet	4800 feet	5400 feet	6000 feet	6600 feet	7200 feet
Fathoms																											
−1 200	−8	+1	−7	−1																							
−1 100	−6	+1	−5	−1																							
−1 000	−6	+1	−5	−1	−2																						
− 900	−5	+1	−4	−1	−2	−2																					
− 800	−4	+1	−3	−1	−2	−2	−3																				
− 700	−3	+1	−2	−1	−2	−2	−3	−3																			
− 600	−2	+1	−1	−1	−1	−1	−2	−3	−4																		
− 500	−2	+1	−1	−1	−1	−1	−2	−2	−3	−3																	
− 400	−1	0	−1	0	−1	−1	−2	−2	−2	−2	−3																
− 300	0	0	0	0	−1	−1	−1	−2	−2	−2	−2	−2															
− 200	0	0	0	0	−1	−1	−1	−1	−1	−2	−2	−1	−1														
− 100	0	0	0	0	−1	−1	−1	−1	−1	−1	−1	−1	−1	−1	0												
Feet.																											
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0												
500	0	0	0	0	+1	+1	+1	+1	+1	+1	+1	+2	+2	+2	+2												
1 000	0	0	0	0	+1	+1	+1	+2	+2	+2	+2	+2	+3	+3	+3	0											
1 500	+1	−1	0	0	+1	+1	+2	+2	+3	+3	+3	+3	+4	+4	+4	0	0										
2 000	+1	−1	0	0	+1	+2	+2	+3	+3	+3	+4	+4	+4	+5	+5	−1	−1	−2									
2 500	+2	−1	+1	0	+1	+2	+3	+3	+4	+4	+5	+5	+5	+6	+6	−1	−1	−2	−3								
3 000	+3	−1	+2	+1	+2	+3	+4	+4	+5	+5	+6	+6	+6	+7	+7	−1	−2	−3	−4	−5							
3 500	+3	−1	+2	+1	+2	+3	+4	+5	+6	+6	+7	+7	+7	+8	+8	−1	−2	−3	−5	−6							
4 000	+4	−1	+3	+1	+3	+4	+5	+5	+6	+6	+7	+8	+8	+9	+9	−1	−2	−4	−5	−7	−7						
4 500	+5	−1	+4	+1	+3	+4	+5	+6	+7	+7	+8	+8	+8	+9	+9	−1	−3	−4	−6	−8	−9	−10					
5 000	+7	−2	+5	+1	+3	+4	+5	+6	+7	+7	+8	+8	+8	+9	+9	−1	−3	−5	−6	−8	−10	−11	−13				
5 200	+8	−2	+6	+1	+3	+4	+5	+6	+7	+7	+8	+8	+8	+9	+9	−1	−3	−5	−7	−9	−10	−12	−14				
5 400	+8	−2	+6	+1	+3	+4	+5	+6	+7	+7	+8	+8	+8	+9	+9	−1	−3	−5	−7	−9	−10	−12	−14	−15			
5 600	+9	−2	+7	+1	+3	+4	+5	+6	+7	+7	+8	+8	+9	+10	+10	−1	−3	−5	−7	−9	−11	−13	−15	−16			
5 800	+9	−2	+7	+2	+3	+5	+6	+6	+7	+7	+8	+8	+9	+10	+10	−1	−3	−5	−7	−9	−11	−13	−15	−16			
6 000	+10	−2	+8	+2	+3	+5	+6	+6	+7	+7	+8	+8	+9	+10	+10	−1	−3	−6	−8	−10	−12	−14	−16	−17	−19		
6 200	+10	−2	+8	+2	+3	+5	+6	+7	+8	+8	+9	+9	+9	+10	+10	−1	−4	−6	−8	−10	−12	−14	−16	−18	−20		
6 400	+11	−2	+9	+2	+3	+5	+6	+7	+8	+8	+9	+9	+9	+10	+10	−2	−4	−6	−8	−11	−13	−15	−17	−19	−21		
6 600	+11	−2	+9	+2	+3	+5	+6	+7	+8	+8	+9	+9	+9	+10	+10	−2	−4	−6	−9	−11	−13	−15	−17	−19	−21	−22	
6 800	+12	−2	+10	+2	+3	+5	+6	+7	+8	+8	+9	+9	+9	+10	+10	−2	−4	−7	−9	−11	−13	−15	−17	−20	−22	−23	
7 000	+12	−2	+10	+2	+3	+5	+6	+7	+8	+8	+9	+9	+9	+10	+10	−2	−4	−7	−9	−11	−13	−15	−18	−20	−22	−23	
7 200	+13	−2	+11	+2	+3	+5	+6	+7	+8	+8	+9	+9	+9	+10	+10	−2	−4	−7	−9	−11	−13	−16	−18	−20	−23	−24	−26
7 400	+13	−2	+11	+2	+3	+5	+6	+7	+8	+8	+9	+9	+9	+10	+10	−2	−4	−7	−9	−11	−14	−16	−18	−21	−23	−25	−27
7 600	+14	−2	+12	+2	+3	+5	+6	+7	+8	+8	+9	+9	+9	+10	+10	−2	−4	−7	−9	−12	−14	−16	−18	−21	−24	−26	−28
7 800	+15	−2	+13	+2	+3	+5	+6	+7	+8	+8	+9	+9	+9	+10	+10	−2	−4	−7	−9	−12	−14	−17	−19	−22	−24	−26	−29
8 000	+16	−3	+13	+2	+3	+5	+6	+7	+8	+8	+9	+9	+9	+10	+10	−2	−4	−7	−9	−12	−14	−17	−19	−22	−24	−27	−29
8 500	+18	−3	+15	+2	+3	+5	+6	+7	+8	+8	+9	+9	+9	+10	+10	−2	−4	−7	−9	−12	−15	−18	−20	−23	−25	−28	−30
9 000	+19	−3	+16	+2	+3	+5	+6	+7	+8	+8	+8	+9	+9	+9	+9	−1	−4	−7	−10	−12	−15	−18	−20	−23	−25	−28	−30
9 500	+20	−3	+17	+2	+3	+5	+6	+7	+8	+8	+8	+8	+9	+9	+9	−1	−4	−7	−10	−12	−15	−18	−20	−23	−26	−29	−31
10 000	+22	−3	+19	+2	+3	+5	+6	+6	+7	+7	+8	+8	+8	+9	+9	−1	−4	−7	−10	−12	−15	−18	−20	−24	−27	−30	−33
10 500	+23	−3	+20	+2	+3	+5	+6	+6	+7	+7	+8	+8	+8	+9	+9	−1	−4	−7	−10	−12	−15	−18	−21	−24	−27	−30	−33
11 000	+25	−3	+22	+2	+3	+5	+6	+6	+7	+7	+7	+8	+8	+8	+8	−1	−4	−7	−10	−13	−15	−18	−21	−24	−28	−31	−34
11 500	+27	−4	+23	+1	+3	+4	+5	+6	+7	+7	+7	+7	+8	+8	+8	−1	−4	−7	−10	−13	−15	−18	−21	−24	−28	−31	−34
12 000	+29	−4	+25	+1	+3	+4	+5	+6	+7	+7	+7	+7	+8	+8	+8	−1	−4	−7	−10	−13	−15	−18	−21	−25	−28	−31	−34
12 500	+30	−4	+26	+1	+3	+4	+5	+6	+7	+7	+7	+7	+7	+7	+7	−1	−4	−7	−10	−13	−15	−18	−21	−25	−28	−32	−35
13 000	+32	−4	+28	+1	+3	+4	+5	+6	+7	+7	+7	+7	+7	+7	+7	−1	−4	−7	−10	−13	−15	−18	−21	−25	−28	−32	−36
13 500	+33	−4	+29	+1	+3	+4	+5	+6	+7	+7	+7	+7	+6	+6	+6	−1	−4	−7	−10	−13	−15	−18	−21	−25	−28	−32	−36
14 000	+34	−4	+30	+1	+3	+4	+5	+6	+7	+7	+7	+6	+6	+6	+6	−1	−4	−7	−10	−12	−15	−18	−21	−25	−28	−32	−36
14 500	+37	−5	+32	+1	+3	+4	+5	+5	+6	+6	+6	+6	+6	+6	+6	−1	−4	−7	−10	−12	−15	−18	−21	−25	−28	−32	−36
15 000	+38	−5	+33	+1	+3	+4	+5	+5	+6	+6	+6	+6	+5	+5	+5	−1	−4	−7	−10	−12	−15	−18	−21	−25	−28	−32	−36

Zone I.

[Inner radius, 5240 meters; outer radius, 8440 meters. Twenty compartments.]

Mean elevation of compartment	Correction for—			Correction for elevation of station—																							
	Topography	Compensation	Topography and compensation	Above compartment												Below compartment											
				1000 feet	2000 feet	3000 feet	4000 feet	5000 feet	6000 feet	7000 feet	8000 feet	9000 feet	10000 feet	11000 feet	12000 feet	1000 feet	2000 feet	3000 feet	4000 feet	5000 feet	6000 feet	7000 feet	8000 feet	9000 feet	10000 feet	11000 feet	12000 feet
Fathoms																											
−2 000	−14	+3	−11	−2																							
−1 800	−11	+2	−9	−2	−3																						
−1 600	−9	+2	−7	−1	−3	−4																					
−1 400	−7	+2	−5	−1	−3	−4	−5																				
−1 200	−5	+2	−3	−1	−2	−4	−5	−6																			
−1 000	−4	+2	−2	−1	−2	−3	−4	−5	−6	−6																	
− 800	−2	+1	−1	−1	−2	−2	−4	−4	−5	−6	−6																
− 600	−2	+1	−1	−1	−1	−2	−3	−3	−4	−4	−4	−5															
− 400	−1	+1	0	−1	−1	−2	−2	−2	−3	−3	−4	−4	−4														
− 200	0	0	0	0	−1	−1	−1	−1	−1	−2	−2	−2	−2	−2													
Feet.																											
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0												
500	0	0	0	0	0	0	+1	+1	+1	+1	+1	+1	+2	+2	+2												
1 000	0	0	0	0	+1	+1	+2	+2	+2	+3	+3	+3	+3	+3	+3	−1											
1 500	+1	−1	0	+1	+1	+2	+2	+2	+3	+3	+4	+4	+4	+4	+4	−1											
2 000	+1	−1	0	+1	+2	+2	+3	+3	+4	+5	+5	+5	+5	+6	+6	−1	−2										
2 500	+1	−1	0	+1	+2	+3	+3	+4	+5	+5	+6	+6	+6	+7	+7	−1	−2										
3 000	+1	−1	0	+1	+2	+3	+4	+5	+5	+6	+7	+7	+7	+8	+8	−1	−2	−4									
3 500	+3	−2	+1	+1	+2	+3	+5	+5	+6	+7	+7	+8	+8	+9	+9	−1	−3	−4									
4 000	+3	−2	+1	+2	+3	+4	+5	+6	+7	+8	+8	+9	+9	+10	+10	−1	−3	−5	−6								
4 500	+4	−2	+2	+2	+3	+4	+6	+6	+7	+8	+9	+9	+10	+10	+10	−2	−4	−5	−7								
5 000	+4	−2	+2	+2	+3	+4	+6	+7	+8	+9	+10	+10	+10	+11	+11	−2	−4	−6	−7	−8							
5 500	+5	−2	+3	+2	+3	+5	+6	+7	+8	+9	+10	+10	+11	+11	+12	−2	−4	−6	−8	−9							
6 000	+6	−2	+4	+2	+4	+5	+7	+8	+9	+10	+11	+11	+11	+12	+12	−2	−5	−7	−9	−11	−13						
6 500	+8	−3	+5	+2	+4	+6	+7	+8	+9	+10	+11	+11	+12	+12	+13	−2	−5	−7	−10	−12	−14						
7 000	+8	−3	+5	+2	+4	+6	+8	+9	+10	+11	+12	+12	+12	+13	+13	−2	−5	−8	−10	−12	−14	−16					
7 500	+9	−3	+6	+2	+4	+6	+8	+9	+10	+11	+12	+12	+13	+13	+14	−2	−5	−8	−10	−13	−15	−17					
8 000	+11	−4	+7	+2	+4	+6	+8	+9	+10	+11	+13	+13	+13	+13	+14	−3	−5	−8	−11	−13	−16	−18	−21				
8 200	+12	−4	+8	+2	+5	+6	+8	+9	+10	+12	+13	+13	+13	+14	+14	−3	−5	−8	−11	−14	−17	−19	−22				
8 400	+12	−4	+8	+2	+5	+6	+8	+9	+11	+12	+13	+13	+13	+14	+14	−3	−5	−8	−11	−14	−17	−19	−22				
8 600	+13	−4	+9	+2	+5	+7	+8	+10	+11	+12	+13	+13	+14	+14	+14	−3	−6	−9	−12	−15	−18	−20	−23				
8 800	+13	−4	+9	+2	+5	+7	+9	+10	+11	+12	+13	+13	+14	+14	+14	−3	−6	−9	−12	−15	−18	−20	−23				
9 000	+13	−4	+9	+2	+5	+7	+9	+10	+11	+12	+13	+13	+14	+14	+14	−3	−6	−9	−12	−15	−18	−21	−23	−26			
9 200	+14	−4	+10	+2	+5	+7	+9	+10	+11	+12	+13	+14	+14	+14	+14	−3	−7	−10	−13	−16	−19	−21	−24	−27			
9 400	+14	−4	+10	+2	+5	+7	+9	+10	+11	+12	+13	+14	+14	+14	+14	−3	−7	−10	−13	−16	−19	−22	−24	−27			
9 600	+15	−4	+11	+2	+5	+7	+9	+10	+11	+12	+13	+14	+14	+14	+15	−3	−7	−10	−13	−16	−19	−22	−25	−28			
9 800	+15	−4	+11	+2	+5	+7	+9	+10	+11	+12	+14	+14	+14	+14	+15	−3	−7	−10	−13	−16	−19	−22	−25	−28			
10 000	+16	−4	+12	+2	+5	+7	+9	+10	+11	+12	+14	+14	+14	+14	+15	−3	−7	−10	−13	−16	−19	−22	−26	−29	−32		
10 200	+17	−5	+12	+3	+5	+7	+9	+10	+11	+12	+14	+14	+14	+14	+15	−3	−7	−10	−13	−16	−20	−23	−26	−29	−32		
10 400	+18	−5	+13	+3	+5	+7	+9	+10	+11	+12	+14	+14	+14	+14	+15	−3	−7	−10	−13	−16	−20	−23	−27	−30	−33		
10 600	+18	−5	+13	+3	+5	+7	+9	+11	+12	+13	+14	+14	+14	+14	+15	−3	−7	−10	−13	−17	−20	−24	−27	−30	−33		
10 800	+19	−5	+14	+3	+5	+7	+9	+11	+12	+13	+14	+14	+14	+14	+15	−3	−7	−10	−14	−17	−21	−24	−28	−31	−34		
11 000	+19	−5	+14	+3	+5	+7	+9	+11	+12	+13	+14	+14	+14	+14	+15	−3	−7	−10	−14	−18	−21	−25	−28	−31	−34	−37	
11 500	+20	−5	+15	+3	+5	+7	+9	+11	+12	+13	+14	+14	+14	+14	+15	−3	−7	−11	−14	−18	−21	−25	−29	−32	−35	−39	
12 000	+22	−5	+17	+3	+6	+8	+10	+11	+12	+13	+14	+14	+14	+14	+15	−3	−7	−11	−15	−18	−22	−26	−30	−33	−37	−40	−43
12 500	+24	−6	+18	+3	+6	+8	+10	+11	+12	+13	+14	+14	+14	+14	+14	−3	−7	−11	−15	−19	−22	−26	−30	−34	−38	−41	−45
13 000	+25	−6	+19	+3	+6	+8	+10	+11	+12	+13	+14	+14	+14	+14	+14	−3	−7	−11	−15	−19	−23	−27	−31	−35	−39	−42	−46
13 500	+26	−6	+20	+3	+6	+8	+10	+11	+12	+13	+14	+14	+14	+14	+14	−3	−7	−11	−15	−19	−23	−27	−31	−36	−40	−43	−47
14 000	+28	−6	+22	+3	+6	+8	+10	+11	+12	+13	+14	+14	+14	+14	+14	−3	−7	−11	−15	−19	−24	−28	−32	−36	−41	−44	−48
14 500	+30	−7	+23	+3	+6	+8	+10	+11	+12	+13	+14	+14	+14	+14	+14	−3	−7	−11	−15	−20	−24	−28	−32	−37	−41	−45	−49
15 000	+31	−7	+24	+3	+6	+8	+9	+11	+11	+12	+13	+13	+13	+13	+13	−3	−7	−11	−15	−20	−24	−28	−33	−38	−42	−46	−50

Zone H.

[Inner radius, 3520 meters; outer radius, 5240 meters. Sixteen compartments.]

Mean elevation of compartment	Correction for—			Correction for elevation of station —																							
	Topography	Compensation	Topography and compensation	Above compartment												Below compartment											
				600 feet	1200 feet	1800 feet	2400 feet	3000 feet	3600 feet	4200 feet	4800 feet	5400 feet	6000 feet	6600 feet	7200 feet	600 feet	1200 feet	1800 feet	2400 feet	3000 feet	3600 feet	4200 feet	4800 feet	5400 feet	6000 feet	6600 feet	7200 feet
Fathoms																											
−1 200	− 8	+1	− 7	−1																							
−1 100	− 6	+1	− 5	−1																							
−1 000	− 6	+1	− 5	−1	−2																						
− 900	− 5	+1	− 4	−1	−2	−2																					
− 800	− 4	+1	− 3	−1	−2	−2	−3																				
− 700	− 3	+1	− 2	−1	−2	−2	−3	−3																			
− 600	− 2	+1	− 1	−1	−1	−1	−2	−3	−4																		
− 500	− 2	+1	− 1	−1	−1	−1	−2	−2	−3	−3																	
− 400	− 1	0	− 1	0	−1	−1	−2	−2	−2	−2	−3																
− 300	0	0	0	0	−1	−1	−1	−2	−2	−2	−2	−2															
− 200	0	0	0	0	−1	−1	−1	−1	−1	−2	−2	−1	−1														
− 100	0	0	0	0	−1	−1	−1	−1	−1	−1	−1	−1	−1	− 1	0												
Feet.																											
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0												
500	0	0	0	0	+1	+1	+1	+1	+1	+1	+1	+2	+2	+ 2	+ 2												
1 000	0	0	0	0	+1	+1	+1	+2	+2	+2	+2	+2	+3	+ 3	+ 3	0											
1 500	+ 1	−1	0	0	+1	+1	+2	+2	+3	+3	+3	+3	+4	+ 4	+ 4	0	0										
2 000	+ 1	−1	0	0	+1	+2	+2	+3	+3	+3	+4	+4	+4	+ 5	+ 5	−1	−1	−2									
2 500	+ 2	−1	+ 1	0	+1	+2	+3	+3	+4	+4	+5	+5	+5	+ 6	+ 6	−1	−1	−2	− 3								
3 000	+ 3	−1	+ 2	+1	+2	+3	+4	+4	+5	+5	+6	+6	+6	+ 7	+ 7	−1	−2	−3	− 4	− 5							
3 500	+ 3	−1	+ 2	+1	+2	+3	+4	+5	+6	+6	+7	+7	+7	+ 8	+ 8	−1	−2	−3	− 5	− 6							
4 000	+ 4	−1	+ 3	+1	+3	+4	+5	+5	+6	+6	+7	+8	+8	+ 9	+ 9	−1	−2	−4	− 5	− 7	− 7						
4 500	+ 5	−1	+ 4	+1	+3	+4	+5	+6	+7	+7	+8	+8	+8	+ 9	+ 9	−1	−3	−4	− 6	− 8	− 9	−10					
5 000	+ 7	−2	+ 5	+1	+3	+4	+5	+6	+7	+7	+8	+8	+8	+ 9	+ 9	−1	−3	−5	− 6	− 8	−10	−11	−13				
5 200	+ 8	−2	+ 6	+1	+3	+4	+5	+6	+7	+7	+8	+8	+8	+ 9	+ 9	−1	−3	−5	− 7	− 9	−10	−12	−14				
5 400	+ 8	−2	+ 6	+1	+3	+4	+5	+6	+7	+7	+8	+8	+8	+ 9	+ 9	−1	−3	−5	− 7	− 9	−10	−12	−14	−15			
5 600	+ 9	−2	+ 7	+1	+3	+4	+5	+6	+7	+7	+8	+8	+9	+10	+10	−1	−3	−5	− 7	− 9	−11	−13	−15	−16			
5 800	+ 9	−2	+ 7	+2	+3	+5	+6	+6	+7	+7	+8	+8	+9	+10	+10	−1	−3	−5	− 7	− 9	−11	−13	−15	−16			
6 000	+10	−2	+ 8	+2	+3	+5	+6	+6	+7	+7	+8	+8	+9	+10	+10	−1	−3	−6	− 8	−10	−12	−14	−16	−17	−19		
6 200	+10	−2	+ 8	+2	+3	+5	+6	+7	+8	+8	+9	+9	+9	+10	+10	−1	−4	−6	− 8	−10	−12	−14	−16	−18	−20		
6 400	+11	−2	+ 9	+2	+3	+5	+6	+7	+8	+8	+9	+9	+9	+10	+10	−2	−4	−6	− 8	−11	−13	−15	−17	−19	−21		
6 600	+11	−2	+ 9	+2	+3	+5	+6	+7	+8	+8	+9	+9	+9	+10	+10	−2	−4	−6	− 9	−11	−13	−15	−17	−19	−21	−22	
6 800	+12	−2	+10	+2	+3	+5	+6	+7	+8	+8	+9	+9	+9	+10	+10	−2	−4	−7	− 9	−11	−13	−15	−17	−20	−22	−23	
7 000	+12	−2	+10	+2	+3	+5	+6	+7	+8	+8	+9	+9	+9	+10	+10	−2	−4	−7	− 9	−11	−13	−15	−18	−20	−22	−23	
7 200	+13	−2	+11	+2	+3	+5	+6	+7	+8	+8	+9	+9	+9	+10	+10	−2	−4	−7	− 9	−11	−13	−16	−18	−20	−23	−24	−26
7 400	+13	−2	+11	+2	+3	+5	+6	+7	+8	+8	+9	+9	+9	+10	+10	−2	−4	−7	− 9	−11	−14	−16	−18	−21	−23	−25	−27
7 600	+14	−2	+12	+2	+3	+5	+6	+7	+8	+8	+9	+9	+9	+10	+10	−2	−4	−7	− 9	−12	−14	−16	−18	−21	−24	−26	−28
7 800	+15	−2	+13	+2	+3	+5	+6	+7	+8	+8	+9	+9	+9	+10	+10	−2	−4	−7	− 9	−12	−14	−17	−19	−22	−24	−26	−29
8 000	+16	−3	+13	+2	+3	+5	+6	+7	+8	+8	+9	+9	+9	+10	+10	−2	−4	−7	− 9	−12	−14	−17	−19	−22	−24	−27	−29
8 500	+18	−3	+15	+2	+3	+5	+6	+7	+8	+8	+9	+9	+9	+10	+10	−2	−4	−7	− 9	−12	−15	−18	−20	−23	−25	−28	−30
9 000	+19	−3	+16	+2	+3	+5	+6	+7	+8	+8	+8	+9	+9	+ 9	+ 9	−1	−4	−7	−10	−12	−15	−18	−20	−23	−25	−28	−30
9 500	+20	−3	+17	+2	+3	+5	+6	+7	+8	+8	+8	+8	+9	+ 9	+ 9	−1	−4	−7	−10	−12	−15	−18	−20	−23	−26	−29	−31
10 000	+22	−3	+19	+2	+3	+5	+6	+6	+7	+7	+8	+8	+8	+ 9	+ 9	−1	−4	−7	−10	−12	−15	−18	−20	−24	−27	−30	−33
10 500	+23	−3	+20	+2	+3	+5	+6	+6	+7	+7	+8	+8	+8	+ 9	+ 9	−1	−4	−7	−10	−12	−15	−18	−21	−24	−27	−30	−33
11 000	+25	−3	+22	+2	+3	+5	+6	+6	+7	+7	+7	+8	+8	+ 8	+ 8	−1	−4	−7	−10	−13	−15	−18	−21	−24	−28	−31	−34
11 500	+27	−4	+23	+1	+3	+4	+5	+6	+7	+7	+7	+7	+8	+ 8	+ 8	−1	−4	−7	−10	−13	−15	−18	−21	−24	−28	−31	−34
12 000	+29	−4	+25	+1	+3	+4	+5	+6	+7	+7	+7	+7	+8	+ 8	+ 8	−1	−4	−7	−10	−13	−15	−18	−21	−25	−28	−31	−34
12 500	+30	−4	+26	+1	+3	+4	+5	+6	+7	+7	+7	+7	+7	+ 7	+ 7	−1	−4	−7	−10	−13	−15	−18	−21	−25	−28	−32	−35
13 000	+32	−4	+28	+1	+3	+4	+5	+6	+7	+7	+7	+7	+7	+ 7	+ 7	−1	−4	−7	−10	−13	−15	−18	−21	−25	−28	−32	−36
13 500	+33	−4	+29	+1	+3	+4	+5	+6	+7	+7	+7	+7	+6	+ 6	+ 6	−1	−4	−7	−10	−13	−15	−18	−21	−25	−28	−32	−36
14 000	+34	−4	+30	+1	+3	+4	+5	+6	+7	+7	+7	+6	+6	+ 6	+ 6	−1	−4	−7	−10	−12	−15	−18	−21	−25	−28	−32	−36
14 500	+37	−5	+32	+1	+3	+4	+5	+5	+6	+6	+6	+6	+6	+ 6	+ 6	−1	−4	−7	−10	−12	−15	−18	−21	−25	−28	−32	−36
15 000	+38	−5	+33	+1	+3	+4	+5	+5	+6	+6	+6	+6	+5	+ 5	+ 5	−1	−4	−7	−10	−12	−15	−18	−21	−25	−28	−32	−36

Zone I.

[Inner radius, 5240 meters; outer radius, 8440 meters. Twenty compartments.]

Mean elevation of compartment	Correction for—			Correction for elevation of station—																							
	Topography	Compensation	Topography and compensation	Above compartment												Below compartment											
				1000 feet	2000 feet	3000 feet	4000 feet	5000 feet	6000 feet	7000 feet	8000 feet	9000 feet	10000 feet	11000 feet	12000 feet	1000 feet	2000 feet	3000 feet	4000 feet	5000 feet	6000 feet	7000 feet	8000 feet	9000 feet	10000 feet	11000 feet	12000 feet
Fathoms																											
−2 000	−14	+3	−11	−2																							
−1 800	−11	+2	− 9	−2	−3																						
−1 600	− 9	+2	− 7	−1	−3	−4																					
−1 400	− 7	+2	− 5	−1	−3	−4	− 5																				
−1 200	− 5	+2	− 3	−1	−2	−4	− 5	− 6																			
−1 000	− 4	+2	− 2	−1	−2	−3	− 4	− 5	− 6	− 6																	
− 800	− 2	+1	− 1	−1	−2	−2	− 4	− 4	− 5	− 6	− 6																
− 600	− 2	+1	− 1	−1	−1	−2	− 3	− 3	− 4	− 4	− 4	− 5															
− 400	− 1	+1	0	−1	−1	−2	− 2	− 2	− 3	− 3	− 4	− 4	− 4														
− 200	0	0	0	0	−1	−1	− 1	− 1	− 1	− 2	− 2	− 2	− 2	− 2													
Feet.																											
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0												
500	0	0	0	0	0	0	+ 1	+ 1	+ 1	+ 1	+ 1	+ 1	+ 2	+ 2	+ 2												
1 000	0	0	0	0	+1	+1	+ 2	+ 2	+ 2	+ 3	+ 3	+ 3	+ 3	+ 3	+ 3	−1											
1 500	+ 1	−1	0	+1	+1	+2	+ 2	+ 2	+ 3	+ 3	+ 4	+ 4	+ 4	+ 4	+ 4	−1											
2 000	+ 1	−1	0	+1	+2	+2	+ 3	+ 3	+ 4	+ 5	+ 5	+ 5	+ 5	+ 6	+ 6	−1	−2										
2 500	+ 1	−1	0	+1	+2	+3	+ 3	+ 4	+ 5	+ 5	+ 6	+ 6	+ 6	+ 7	+ 7	−1	−2										
3 000	+ 1	−1	0	+1	+2	+3	+ 4	+ 5	+ 5	+ 6	+ 7	+ 7	+ 7	+ 8	+ 8	−1	−2	− 4									
3 500	+ 3	−2	+ 1	+1	+2	+3	+ 5	+ 5	+ 6	+ 7	+ 7	+ 8	+ 8	+ 9	+ 9	−1	−3	− 4									
4 000	+ 3	−2	+ 1	+2	+3	+4	+ 5	+ 6	+ 7	+ 8	+ 8	+ 9	+ 9	+10	+10	−1	−3	− 5	− 6								
4 500	+ 4	−2	+ 2	+2	+3	+4	+ 6	+ 6	+ 7	+ 8	+ 9	+ 9	+10	+10	+10	−2	−4	− 5	− 7								
5 000	+ 4	−2	+ 2	+2	+3	+4	+ 6	+ 7	+ 8	+ 9	+10	+10	+10	+11	+11	−2	−4	− 6	− 7	− 8							
5 500	+ 5	−2	+ 3	+2	+3	+5	+ 6	+ 7	+ 8	+ 9	+10	+10	+11	+11	+12	−2	−4	− 6	− 8	− 9							
6 000	+ 6	−2	+ 4	+2	+4	+5	+ 7	+ 8	+ 9	+10	+11	+11	+11	+12	+12	−2	−5	− 7	− 9	−11	−13						
6 500	+ 8	−3	+ 5	+2	+4	+6	+ 7	+ 8	+ 9	+10	+11	+11	+12	+12	+13	−2	−5	− 7	−10	−12	−14						
7 000	+ 8	−3	+ 5	+2	+4	+6	+ 8	+ 9	+10	+11	+12	+12	+12	+13	+13	−2	−5	− 8	−10	−12	−14	−16					
7 500	+ 9	−3	+ 6	+2	+4	+6	+ 8	+ 9	+10	+11	+12	+12	+13	+13	+14	−2	−5	− 8	−10	−13	−15	−17					
8 000	+11	−4	+ 7	+2	+4	+6	+ 8	+ 9	+10	+11	+13	+13	+13	+13	+14	−3	−5	− 8	−11	−13	−16	−18	−21				
8 200	+12	−4	+ 8	+2	+5	+6	+ 8	+ 9	+10	+12	+13	+13	+13	+14	+14	−3	−5	− 8	−11	−14	−17	−19	−22				
8 400	+12	−4	+ 8	+2	+5	+6	+ 8	+ 9	+11	+12	+13	+13	+13	+14	+14	−3	−5	− 8	−11	−14	−17	−19	−22				
8 600	+13	−4	+ 9	+2	+5	+7	+ 8	+10	+11	+12	+13	+13	+14	+14	+14	−3	−6	− 9	−12	−15	−18	−20	−23				
8 800	+13	−4	+ 9	+2	+5	+7	+ 9	+10	+11	+12	+13	+13	+14	+14	+14	−3	−6	− 9	−12	−15	−18	−20	−23				
9 000	+13	−4	+ 9	+2	+5	+7	+ 9	+10	+11	+12	+13	+13	+14	+14	+14	−3	−6	− 9	−12	−15	−18	−21	−23	−26			
9 200	+14	−4	+10	+2	+5	+7	+ 9	+10	+11	+12	+13	+14	+14	+14	+14	−3	−7	−10	−13	−16	−19	−21	−24	−27			
9 400	+14	−4	+10	+2	+5	+7	+ 9	+10	+11	+12	+13	+14	+14	+14	+14	−3	−7	−10	−13	−16	−19	−22	−24	−27			
9 600	+15	−4	+11	+2	+5	+7	+ 9	+10	+11	+12	+13	+14	+14	+14	+15	−3	−7	−10	−13	−16	−19	−22	−25	−28			
9 800	+15	−4	+11	+2	+5	+7	+ 9	+10	+11	+12	+14	+14	+14	+14	+15	−3	−7	−10	−13	−16	−19	−22	−25	−28			
10 000	+16	−4	+12	+2	+5	+7	+ 9	+10	+11	+12	+14	+14	+14	+14	+15	−3	−7	−10	−13	−16	−19	−22	−26	−29	−32		
10 200	+17	−5	+12	+3	+5	+7	+ 9	+10	+11	+12	+14	+14	+14	+14	+15	−3	−7	−10	−13	−16	−20	−23	−26	−29	−32		
10 400	+18	−5	+13	+3	+5	+7	+ 9	+10	+11	+12	+14	+14	+14	+14	+15	−3	−7	−10	−13	−16	−20	−23	−27	−30	−33		
10 600	+18	−5	+13	+3	+5	+7	+ 9	+11	+12	+13	+14	+14	+14	+14	+15	−3	−7	−10	−13	−17	−20	−24	−27	−30	−33		
10 800	+19	−5	+14	+3	+5	+7	+ 9	+11	+12	+13	+14	+14	+14	+14	+15	−3	−7	−10	−14	−17	−21	−24	−28	−31	−34		
11 000	+19	−5	+14	+3	+5	+7	+ 9	+11	+12	+13	+14	+14	+14	+14	+15	−3	−7	−10	−14	−18	−21	−25	−28	−31	−34	−37	
11 500	+20	−5	+15	+3	+5	+7	+ 9	+11	+12	+13	+14	+14	+14	+14	+15	−3	−7	−11	−14	−18	−21	−25	−29	−32	−35	−39	
12 000	+22	−5	+17	+3	+6	+8	+10	+11	+12	+13	+14	+14	+14	+14	+15	−3	−7	−11	−15	−18	−22	−26	−30	−33	−37	−40	−43
12 500	+24	−6	+18	+3	+6	+8	+10	+11	+12	+13	+14	+14	+14	+14	+14	−3	−7	−11	−15	−19	−22	−26	−30	−34	−38	−41	−45
13 000	+25	−6	+19	+3	+6	+8	+10	+11	+12	+13	+14	+14	+14	+14	+14	−3	−7	−11	−15	−19	−23	−27	−31	−35	−39	−42	−46
13 500	+26	−6	+20	+3	+6	+8	+10	+11	+12	+13	+14	+14	+14	+14	+14	−3	−7	−11	−15	−19	−23	−27	−31	−36	−40	−43	−47
14 000	+28	−6	+22	+3	+6	+8	+10	+11	+12	+13	+14	+14	+14	+14	+14	−3	−7	−11	−15	−19	−24	−28	−32	−36	−41	−44	−48
14 500	+30	−7	+23	+3	+6	+8	+10	+11	+12	+13	+14	+14	+14	+14	+14	−3	−7	−11	−15	−20	−24	−28	−32	−37	−41	−45	−49
15 000	+31	−7	+24	+3	+6	+8	+ 9	+11	+11	+12	+13	+13	+13	+13	+13	−3	−7	−11	−15	−20	−24	−28	−33	−38	−42	−46	−50

Zone J.

[Inner radius, 8440 meters; outer radius, 12 400 meters. Sixteen compartments.]

Mean elevation of compartment	Correction for—			Correction for elevation of station—																							
				Above compartment												Below compartment											
	Topography	Compensation	Topography and compensation	1000 feet	2000 feet	3000 feet	4000 feet	5000 feet	6000 feet	7000 feet	8000 feet	9000 feet	10000 feet	11000 feet	12000 feet	1000 feet	2000 feet	3000 feet	4000 feet	5000 feet	6000 feet	7000 feet	8000 feet	9000 feet	10000 feet	11000 feet	12000 feet
Fathoms																											
−1 200	− 4	+ 3	− 1	−1	−2	−3	− 4																				
− 800	− 2	+ 2	0	−1	−1	−2	− 3	− 4	− 4	− 4																	
− 400	0	+ 1	+ 1	−1	−1	−1	− 1	− 2	− 2	− 2	− 2	− 3															
Feet																											
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0												
1 000	0	− 1	− 1	0	+1	+1	+ 1	+ 1	+ 1	+ 1	+ 2	+ 2	+ 2	+ 2	+ 2	+1											
2 000	0	− 1	− 1	+1	+2	+2	+ 2	+ 3	+ 3	+ 4	+ 4	+ 4	+ 4	+ 4	+ 5	0	−1										
3 000	+ 1	− 2	− 1	+1	+2	+2	+ 3	+ 4	+ 4	+ 5	+ 5	+ 6	+ 6	+ 6	+ 7	0	−1	−2									
4 000	+ 2	− 3	− 1	+1	+2	+3	+ 4	+ 5	+ 5	+ 6	+ 6	+ 7	+ 8	+ 8	+ 9	0	−1	−2	− 3								
5 000	+ 3	− 3	0	+1	+2	+4	+ 5	+ 6	+ 6	+ 7	+ 8	+ 9	+10	+10	+11	−1	−1	−2	− 4	− 7							
6 000	+ 4	− 4	0	+1	+3	+4	+ 5	+ 7	+ 8	+ 8	+ 9	+10	+12	+13	+13	−1	−1	−3	− 5	− 7	− 8						
7 000	+ 6	− 5	+ 1	+2	+3	+5	+ 7	+ 8	+ 9	+10	+11	+12	+13	+14	+14	−2	−3	−4	− 6	− 8	−10	−11					
8 000	+ 7	− 5	+ 2	+2	+4	+5	+ 7	+ 8	+10	+11	+12	+13	+14	+15	+16	−2	−4	−5	− 7	− 9	−11	−13	−15				
8 500	+ 8	− 5	+ 3	+2	+4	+6	+ 7	+ 9	+10	+11	+12	+13	+14	+15	+16	−2	−4	−6	− 7	−10	−12	−14	−16				
9 000	+ 9	− 6	+ 3	+2	+4	+6	+ 7	+ 9	+10	+11	+12	+14	+15	+16	+17	−2	−4	−6	− 8	−10	−12	−15	−17	−18			
9 500	+10	− 6	+ 4	+2	+4	+6	+ 7	+ 9	+11	+12	+13	+14	+15	+16	+17	−2	−4	−6	− 8	−11	−13	−16	−18	−20			
10 000	+12	− 7	+ 5	+2	+4	+6	+ 8	+ 9	+11	+12	+13	+14	+15	+17	+18	−2	−5	−7	− 9	−11	−14	−16	−19	−21	−24		
10 500	+13	− 7	+ 6	+2	+4	+6	+ 8	+10	+11	+12	+13	+15	+16	+17	+18	−2	−5	−7	−10	−12	−14	−17	−20	−22	−25		
11 000	+14	− 7	+ 7	+2	+4	+6	+ 8	+10	+12	+13	+14	+15	+16	+18	+19	−2	−5	−7	−10	−12	−15	−18	−21	−24	−27	−29	
11 500	+15	− 8	+ 7	+2	+4	+7	+ 8	+10	+12	+13	+14	+16	+17	+18	+19	−2	−5	−8	−10	−13	−15	−18	−21	−24	−27	−29	
12 000	+16	− 8	+ 8	+2	+4	+7	+ 9	+11	+12	+14	+15	+16	+17	+18	+20	−2	−5	−8	−10	−13	−16	−19	−22	−25	−28	−30	−32
12 500	+17	− 8	+ 9	+2	+5	+7	+ 9	+11	+13	+14	+15	+16	+17	+19	+20	−2	−5	−8	−10	−14	−17	−20	−22	−26	−29	−31	−33
13 000	+19	− 9	+10	+2	+5	+7	+ 9	+11	+13	+14	+15	+16	+18	+19	+20	−2	−5	−8	−11	−14	−17	−20	−23	−27	−30	−32	−35
13 500	+20	− 9	+11	+3	+5	+7	+ 9	+11	+13	+14	+16	+17	+18	+19	+20	−2	−6	−8	−11	−14	−17	−21	−24	−28	−31	−33	−36
14 000	+21	− 9	+12	+3	+5	+7	+ 9	+11	+13	+14	+16	+17	+19	+20	+21	−2	−6	−8	−11	−14	−18	−21	−25	−28	−32	−34	−37
14 500	+23	−10	+13	+3	+5	+8	+10	+11	+13	+14	+16	+17	+19	+20	+21	−2	−6	−9	−11	−15	−18	−22	−26	−29	−32	−35	−38
15 000	+24	−10	+14	+3	+6	+8	+10	+12	+14	+15	+17	+18	+19	+20	+21	−2	−6	−9	−11	−15	−19	−22	−26	−29	−33	−36	−39

Zone K.

[Inner radius, 12 400 meters; outer radius, 18 800 meters. Twenty compartments.]

Mean elevation of compartment	Correction for—			Correction for elevation of station—																							
	Topography	Compensation	Topography and compensation	Above compartment												Below compartment											
				600 feet	1200 feet	1800 feet	2400 feet	3000 feet	3600 feet	4200 feet	4800 feet	5400 feet	6000 feet	6600 feet	7200 feet	600 feet	1200 feet	1800 feet	2400 feet	3000 feet	3600 feet	4200 feet	4800 feet	5400 feet	6000 feet	6600 feet	7200 feet
Fathoms																											
−1 200	− 3	+ 4	+1	−1	−1	−1																					
− 800	− 1	+ 2	+1	0	−1	−1	−1	−1	−1	−1																	
− 400	0	+ 1	+1	0	−1	−1	−1	−1	−1	−1	−1	−1	− 1	− 1	− 1												
Feet																											
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0												
1 000	0	− 1	−1	0	0	0	0	+1	+1	+1	+1	+1	+ 1	+ 1	+ 1	0											
2 000	0	− 1	−1	0	+1	+1	+1	+1	+1	+1	+2	+2	+ 2	+ 2	+ 2	0	−1	−1									
3 000	0	− 2	−2	0	+1	+1	+1	+2	+2	+2	+2	+2	+ 2	+ 3	+ 3	0	−1	−1	−1	−1							
4 000	+ 1	− 3	−2	0	+1	+1	+1	+2	+2	+2	+3	+3	+ 3	+ 4	+ 4	0	−1	−2	−2	−2	−2						
5 000	+ 2	− 4	−2	0	+1	+1	+1	+2	+2	+3	+3	+4	+ 4	+ 5	+ 5	0	−1	−2	−3	−3	−3	−4	− 4				
6 000	+ 3	− 5	−2	+1	+1	+2	+2	+3	+3	+3	+4	+4	+ 5	+ 5	+ 6	0	−1	−2	−3	−3	−3	−4	− 5	− 5	− 6		
7 000	+ 4	− 6	−2	+1	+1	+2	+2	+3	+3	+4	+4	+5	+ 6	+ 6	+ 7	0	−1	−2	−3	−3	−4	−4	− 5	− 6	− 6	− 7	
8 000	+ 5	− 7	−2	+1	+1	+2	+3	+3	+4	+5	+5	+6	+ 6	+ 7	+ 7	0	−1	−2	−3	−3	−4	−5	− 6	− 6	− 7	− 8	− 8
8 500	+ 5	− 7	−2	+1	+1	+2	+3	+3	+4	+5	+5	+6	+ 7	+ 7	+ 8	0	−1	−2	−3	−4	−4	−5	− 6	− 7	− 8	− 8	− 9
9 000	+ 5	− 7	−2	+1	+1	+2	+3	+3	+4	+5	+5	+6	+ 7	+ 7	+ 8	0	−1	−2	−3	−4	−4	−5	− 6	− 7	− 8	− 9	− 9
9 500	+ 6	− 8	−2	+1	+1	+2	+3	+4	+5	+6	+6	+7	+ 8	+ 8	+ 9	0	−1	−2	−3	−4	−4	−5	− 6	− 7	− 8	− 9	−10
10 000	+ 7	− 8	−1	+1	+1	+2	+3	+4	+5	+6	+6	+7	+ 8	+ 8	+ 9	0	−1	−2	−4	−4	−5	−6	− 7	− 8	− 9	−10	−11
10 500	+ 8	− 9	−1	+1	+1	+2	+3	+4	+5	+6	+6	+7	+ 8	+ 8	+ 9	0	−1	−2	−4	−5	−5	−6	− 7	− 8	− 9	−10	−11
11 000	+ 8	− 9	−1	+1	+2	+3	+4	+4	+5	+6	+7	+7	+ 8	+ 9	+10	0	−1	−3	−4	−5	−5	−6	− 7	− 8	− 9	−10	−11
11 500	+ 9	− 9	0	+1	+2	+3	+4	+4	+5	+6	+7	+8	+ 9	+ 9	+10	0	−2	−3	−5	−5	−6	−7	− 8	− 9	−10	−11	−12
12 000	+10	−10	0	+1	+2	+3	+4	+4	+5	+6	+7	+8	+ 9	+ 9	+10	0	−2	−3	−5	−6	−6	−7	− 8	− 9	−10	−11	−12
12 500	+10	−10	0	+1	+2	+3	+4	+5	+6	+6	+7	+8	+ 9	+10	+11	0	−2	−3	−5	−6	−6	−7	− 8	− 9	−10	−11	−12
13 000	+12	−11	+1	+1	+2	+3	+4	+5	+6	+7	+8	+8	+ 9	+10	+11	−1	−2	−3	−5	−6	−7	−8	− 9	−10	−11	−12	−13
13 500	+12	−11	+1	+1	+2	+3	+4	+5	+6	+7	+8	+9	+10	+10	+11	−1	−2	−4	−5	−6	−7	−8	− 9	−10	−11	−12	−13
14 000	+13	−11	+2	+1	+2	+3	+4	+5	+6	+7	+8	+9	+10	+10	+11	−1	−2	−4	−5	−6	−7	−8	−10	−11	−12	−13	−14
14 500	+14	−12	+2	+1	+2	+3	+4	+5	+6	+7	+8	+9	+10	+11	+12	−1	−2	−4	−5	−6	−7	−8	−10	−11	−12	−13	−14
15 000	+15	−12	+3	+1	+2	+3	+4	+5	+6	+7	+8	+9	+10	+11	+12	−1	−2	−4	−5	−6	−7	−9	−10	−12	−13	−14	−14

Zone L.

[Inner radius, 18 800 meters; outer radius, 28 800 meters. Twenty-four compartments.]

Mean elevation of compartment	Correction for—			Correction for elevation of station—																							
	Topography	Compensation	Topography and compensation	Above compartment												Below compartment											
				700 feet	1400 feet	2100 feet	2800 feet	3500 feet	4200 feet	4900 feet	5600 feet	6300 feet	7000 feet	7700 feet	8400 feet	700 feet	1400 feet	2100 feet	2800 feet	3580 feet	4200 feet	4900 feet	5600 feet	6300 feet	7000 feet	7700 feet	8400 feet
Fathoms																											
−1 500	−2	+ 6	+4	0																							
−1 200	−1	+ 4	+3	0	−1	−1																					
− 900	−1	+ 3	+2	0	−1	−1	−1	−1	−1	−1																	
− 600	0	+ 2	+2	0	−1	−1	−1	−1	−1	−1	−1																
− 300	0	+ 1	+1	0	0	0	0	−1	−1	−1	−1	−1	−1	−1	−1												
Feet																											
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0												
1 000	0	− 1	−1	0	0	0	0	0	0	0	+1	+1	+1	+1	+1	0											
2 000	0	− 2	−2	0	0	0	0	+1	+1	+1	+1	+1	+1	+1	+1	0	0										
3 000	0	− 3	−3	0	0	0	0	+1	+1	+1	+2	+2	+2	+2	+2	0	0	0	−1								
4 000	+1	− 4	−3	0	+1	+1	+1	+1	+1	+1	+2	+2	+2	+3	+3	0	−1	−1	−1	−1							
5 000	+1	− 5	−4	0	+1	+1	+1	+2	+2	+2	+3	+3	+3	+3	+3	0	−1	−1	−1	−2	−2	−2					
6 000	+1	− 5	−4	0	+1	+1	+1	+2	+2	+2	+3	+3	+4	+4	+4	0	−1	−1	−1	−2	−2	−2	−3				
7 000	+2	− 7	−5	0	+1	+1	+1	+2	+2	+3	+3	+4	+4	+5	+5	0	−1	−1	−2	−2	−2	−3	−3	−4	−4		
8 000	+3	− 8	−5	0	+1	+1	+2	+2	+3	+3	+4	+4	+4	+5	+5	0	−1	−1	−2	−2	−3	−3	−4	−4	−4	−5	
8 500	+3	− 9	−6	0	+1	+1	+2	+2	+3	+3	+4	+4	+5	+5	+5	0	−1	−1	−2	−2	−3	−3	−4	−4	−5	−5	
9 000	+3	− 9	−6	0	+1	+1	+2	+2	+3	+3	+4	+4	+5	+5	+6	0	−1	−1	−2	−2	−3	−3	−4	−4	−5	−5	− 6
9 500	+3	− 9	−6	0	+1	+2	+2	+3	+3	+4	+4	+5	+5	+6	+6	0	−1	−2	−2	−3	−3	−4	−4	−5	−5	−6	− 6
10 000	+4	−10	−6	+1	+1	+2	+2	+3	+3	+4	+4	+5	+5	+6	+6	−1	−1	−2	−2	−3	−3	−4	−4	−5	−6	−6	− 7
10 500	+4	−10	−6	+1	+1	+2	+2	+3	+3	+4	+4	+5	+6	+6	+7	−1	−1	−2	−2	−3	−3	−4	−4	−5	−6	−7	− 7
11 000	+5	−11	−6	+1	+1	+2	+2	+3	+3	+4	+4	+5	+6	+6	+7	−1	−1	−2	−2	−3	−3	−4	−4	−5	−6	−7	− 7
11 500	+5	−11	−6	+1	+1	+2	+3	+3	+4	+4	+5	+5	+6	+6	+7	−1	−1	−2	−3	−3	−4	−4	−5	−5	−6	−7	− 8
12 000	+6	−12	−6	+1	+1	+2	+3	+3	+4	+5	+5	+6	+6	+7	+7	−1	−1	−2	−3	−3	−4	−5	−5	−6	−6	−7	− 8
12 500	+6	−12	−6	+1	+1	+2	+3	+3	+4	+5	+5	+6	+7	+7	+8	−1	−1	−2	−3	−3	−4	−5	−5	−6	−7	−8	− 9
13 000	+7	−13	−6	+1	+1	+2	+3	+3	+4	+5	+5	+6	+7	+7	+8	−1	−1	−2	−3	−3	−4	−5	−5	−6	−7	−8	− 9
14 000	+8	−14	−6	+1	+1	+2	+3	+3	+4	+5	+5	+6	+7	+7	+8	−1	−1	−2	−3	−3	−4	−5	−5	−6	−7	−8	− 9
15 000	+9	−15	−6	+1	+2	+3	+4	+4	+5	+6	+6	+7	+8	+8	+9	−1	−2	−3	−3	−4	−5	−6	−6	−7	−8	−9	−10

Zone M.

[Inner radius, 28 800 meters; outer radius, 58 800 meters. Fourteen compartments.]

Mean elevation of compartment	Correction for—			Correction for elevation of station—																								
	Topography	Compensation	Topography and compensation	At same elevation as compartment	Above compartment												Below compartment											
					700 feet	1400 feet	2100 feet	2800 feet	3500 feet	4200 feet	4900 feet	5600 feet	6300 feet	7000 feet	7700 feet	8400 feet	700 feet	1400 feet	2100 feet	2800 feet	3500 feet	4200 feet	4900 feet	5600 feet	6300 feet	7000 feet	7700 feet	8400 feet
Fathoms																												
−1 500	− 3	+23	+20		−1																							
−1 200	− 2	+19	+17		−1	−1	−1																					
− 900	− 1	+14	+13		−1	−1	−1	−1	−2	−2																		
− 600	− 1	+10	+ 9		0	0	−1	−1	−1	−1	−2	− 2																
− 300	0	+ 4	+ 4		0	0	0	0	−1	−1	−1	− 1	− 1	− 1	− 2	− 2												
Feet																												
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0												
1 000	0	− 4	− 4	0	0	0	+1	+1	+1	+1	+1	+ 1	+ 1	+ 1	+ 2	+ 2	0											
2 000	0	− 8	− 8	0	0	0	+1	+1	+1	+1	+1	+ 2	+ 2	+ 2	+ 3	+ 3	0	0										
3 000	+ 1	−13	−12	0	0	+1	+1	+1	+2	+2	+2	+ 3	+ 3	+ 3	+ 4	+ 4	0	−1	−1	−1								
4 000	+ 1	−17	−16	0	+1	+1	+1	+1	+2	+2	+3	+ 3	+ 4	+ 4	+ 5	+ 5	−1	−1	−1	−1	−2							
5 000	+ 2	−21	−19	0	+1	+1	+2	+2	+3	+3	+3	+ 4	+ 4	+ 5	+ 5	+ 6	−1	−1	−2	−2	−3	−3	−3					
6 000	+ 2	−25	−23	+1	+1	+2	+2	+2	+3	+3	+4	+ 4	+ 5	+ 6	+ 6	+ 7	−1	−2	−2	−2	−3	−3	−4	− 4				
7 000	+ 3	−29	−26	+1	+1	+2	+2	+3	+3	+4	+5	+ 5	+ 6	+ 7	+ 7	+ 8	−1	−2	−2	−3	−3	−4	−5	− 5	− 6	− 7		
8 000	+ 4	−33	−29	+1	+1	+2	+3	+4	+4	+5	+6	+ 6	+ 7	+ 8	+ 8	+ 9	−1	−2	−3	−4	−4	−5	−6	− 6	− 7	− 8	− 8	
8 500	+ 5	−35	−30	+1	+1	+2	+3	+4	+4	+5	+6	+ 6	+ 7	+ 8	+ 8	+ 9	−1	−2	−3	−4	−4	−5	−6	− 6	− 7	− 8	− 8	
9 000	+ 5	−37	−32	+1	+2	+2	+3	+4	+4	+5	+6	+ 6	+ 7	+ 8	+ 9	+10	−2	−2	−3	−4	−4	−5	−6	− 6	− 7	− 8	− 8	− 9
9 500	+ 6	−39	−33	+1	+2	+2	+3	+4	+4	+5	+6	+ 7	+ 8	+ 9	+ 9	+10	−2	−2	−3	−4	−4	−5	−6	− 7	− 7	− 8	− 8	− 9
10 000	+ 7	−42	−35	+1	+2	+2	+3	+4	+5	+6	+7	+ 7	+ 8	+10	+10	+11	−2	−2	−3	−4	−5	−6	−7	− 7	− 8	− 9	− 9	−10
10 500	+ 7	−43	−36	+1	+2	+3	+3	+4	+5	+6	+7	+ 8	+ 9	+10	+10	+11	−2	−3	−3	−4	−5	−6	−7	− 8	− 8	− 9	− 9	−10
11 000	+ 8	−46	−38	+1	+2	+3	+3	+4	+5	+6	+7	+ 8	+ 9	+10	+11	+12	−2	−3	−3	−4	−5	−6	−7	− 8	− 8	− 9	−10	−11
11 500	+ 9	−48	−39	+1	+2	+3	+3	+4	+5	+6	+7	+ 8	+ 9	+10	+11	+12	−2	−3	−3	−4	−5	−6	−7	− 8	− 8	− 9	−10	−11
12 000	+ 9	−49	−40	+1	+2	+3	+4	+5	+6	+7	+8	+ 9	+10	+11	+12	+13	−2	−3	−4	−5	−6	−7	−7	− 8	− 9	−10	−11	−12
12 500	+10	−52	−42	+1	+2	+3	+4	+5	+6	+7	+8	+ 9	+10	+11	+12	+13	−2	−3	−4	−5	−6	−7	−8	− 8	− 9	−10	−11	−12
13 000	+11	−54	−43	+1	+2	+3	+4	+5	+6	+7	+8	+10	+11	+12	+13	+14	−2	−3	−4	−5	−6	−7	−8	− 9	−10	−11	−12	−13
14 000	+13	−58	−45	+1	+2	+3	+4	+5	+7	+8	+9	+10	+11	+12	+14	+15	−2	−3	−4	−5	−7	−8	−8	− 9	−10	−11	−13	−14
15 000	+15	−62	−47	+1	+2	+3	+4	+5	+7	+8	+9	+11	+12	+13	+15	+16	−2	−3	−4	−5	−7	−8	−9	−10	−11	−12	−14	−15

The distance from the station to the middle of this zone is 43.8 km (=27.2 miles) and the curvature is 495 feet.

Zone N.

[Inner radius, 58 800 meters; outer radius, 99 000 meters. Sixteen compartments.]

Mean elevation of compartment	Correction for—			Correction for elevation of station—																								
	Topography	Compensation	Topography and compensation	At same elevation as compartment	Above compartment												Below compartment											
					700 feet	1400 feet	2100 feet	2800 feet	3500 feet	4200 feet	4900 feet	5600 feet	6300 feet	7000 feet	7700 feet	8400 feet	700 feet	1400 feet	2100 feet	2800 feet	3500 feet	4200 feet	4900 feet	5600 feet	6300 feet	7000 feet	7700 feet	8400 feet
Fathoms																												
−1 500	−1	+18	+17	0	−1																							
−1 200	−1	+15	+14	0	−1	−1	−1																					
− 900	0	+10	+10	0	0	−1	−1	−1	−1	−1																		
− 600	0	+ 7	+ 7	0	0	0	0	0	−1	−1	−1	−1	−1															
− 300	0	+ 4	+ 4	0	0	0	0	0	0	0	0	−1	−1	−1	−1	−1												
Feet																												
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0												
500	0	− 2	− 2	0	0	0	0	0	0	0	0	0	0	0	+1	+1												
1 000	0	− 3	− 3	0	0	0	0	0	0	0	0	0	0	0	+1	+1	0											
1 500	0	− 5	− 5	0	0	0	0	0	0	0	0	+1	+1	+1	+1	+1	0	0										
2 000	0	− 6	− 6	0	0	0	0	0	0	0	0	+1	+1	+1	+1	+1	0	0										
2 500	0	− 8	− 8	0	0	0	0	0	+1	+1	+1	+1	+1	+1	+1	+1	0	0	0									
3 000	0	−10	−10	0	0	0	0	0	+1	+1	+1	+1	+1	+1	+1	+1	0	0	0	0								
3 500	0	−11	−11	0	0	0	0	0	+1	+1	+1	+1	+1	+1	+2	+2	0	0	0	0	0							
4 000	0	−13	−13	0	0	0	0	+1	+1	+1	+1	+1	+1	+1	+2	+2	0	0	0	0	0							
4 500	+1	−15	−14	0	0	0	0	+1	+1	+1	+1	+1	+2	+2	+2	+2	0	0	0	0	0	0						
5 000	+1	−17	−16	0	0	+1	+1	+1	+1	+1	+1	+2	+2	+2	+2	+2	0	0	0	0	0	0	0					
6 000	+1	−20	−19	0	0	+1	+1	+1	+1	+1	+1	+2	+2	+2	+2	+2	0	0	0	0	0	0	0	−1				
7 000	+1	−23	−22	0	+1	+1	+1	+1	+1	+1	+1	+2	+2	+2	+2	+3	0	0	0	0	0	0	0	−1	−1	−1		
8 000	+1	−26	−25	0	+1	+1	+1	+1	+1	+1	+2	+2	+2	+2	+3	+3	0	0	0	−1	−1	−1	−1	−1	−1	−1	−2	
9 000	+2	−30	−28	+1	+1	+1	+1	+1	+1	+2	+2	+2	+2	+3	+3	+3	0	0	0	−1	−1	−1	−1	−1	−1	−2	−2	−2
10 000	+2	−32	−30	+1	+1	+1	+1	+1	+2	+2	+2	+2	+3	+3	+3	+4	0	0	0	−1	−1	−1	−1	−1	−2	−2	−2	−3
11 000	+3	−36	−33	+1	+1	+1	+1	+1	+2	+2	+2	+3	+3	+3	+4	+4	0	0	0	−1	−1	−1	−1	−2	−2	−2	−3	−3
12 000	+3	−39	−36	+1	+1	+1	+1	+2	+2	+2	+2	+3	+3	+3	+4	+4	0	0	0	−1	−1	−1	−1	−2	−2	−2	−3	−3
13 000	+4	−43	−39	+1	+1	+1	+1	+2	+2	+2	+3	+3	+3	+4	+4	+4	0	0	0	−1	−1	−1	−2	−2	−2	−3	−3	−3
14 000	+4	−45	−41	+1	+1	+1	+1	+2	+2	+2	+3	+3	+4	+4	+5	+5	0	0	0	−1	−1	−1	−2	−2	−3	−3	−4	−4
15 000	+5	−49	−44	+1	+1	+1	+1	+2	+3	+3	+3	+4	+4	+4	+5	+5	0	0	0	−1	−2	−2	−2	−2	−3	−3	−4	−4

The distance from the station to the middle of this zone is 78.9 km (=49.0 miles) and the curvature is 1600 feet.

Zone O.

[Inner radius, 99 000 meters; outer radius, 166 700 meters. Twenty-eight compartments.]

Mean elevation of compartment	Correction for—			Correction for elevation of station—																								
					Above compartment												Below compartment											
	Topography	Compensation	Typography and compensation	At same elevation as compartment	800 feet	1600 feet	2400 feet	3200 feet	4000 feet	4800 feet	5600 feet	6400 feet	7200 feet	8000 feet	8800 feet	9600 feet	800 feet	1600 feet	2400 feet	3200 feet	4000 feet	4800 feet	5600 feet	6400 feet	7200 feet	8000 feet	8800 feet	9600 feet
Fathoms																												
−1 800	0	+12	+12	0																								
−1 500	0	+10	+10	0	0	0																						
−1 200	0	+ 8	+ 8	0	0	0	0	0																				
− 900	0	+ 6	+ 6	0	0	0	0	0	0																			
− 600	0	+ 4	+ 4	0	0	0	0	0	0	0	0	0																
− 300	0	+ 2	+ 2	0	0	0	0	0	0	0	0	0	0	0	0													
Feet																												
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0												
500	0	− 1	− 1	0	0	0	0	0	0	0	0	0	0	0	0	0												
1 000	0	− 2	− 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
1 500	0	− 3	− 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
2 000	0	− 4	− 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0										
2 500	0	− 4	− 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0									
3 000	0	− 5	− 5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0									
3 500	0	− 6	− 6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
4 000	0	− 7	− 7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0							
5 000	0	− 9	− 9	0	0	0	0	0	0	0	0	0	0	+1	+1	+1	0	0	0	0	0	0						
6 000	0	−10	−10	0	0	0	0	0	0	0	0	+1	+1	+1	+1	+1	0	0	0	0	0	0	0					
7 000	0	−12	−12	0	0	0	0	0	0	+1	+1	+1	+1	+1	+1	+1	0	0	0	0	0	0	0					
8 000	0	−14	−14	0	0	0	0	+1	+1	+1	+1	+1	+1	+1	+1	+1	0	0	0	0	0	0	0	0	0	0		
9 000	+1	−16	−15	0	0	0	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	0	0	0	0	0	0	0	0	0	0	0	
10 000	+1	−18	−17	0	0	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	0	0	0	0	0	0	0	0	0	0	0	−1
11 000	+1	−20	−19	0	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	0	0	0	0	0	0	0	0	0	0	0	−1
12 000	+1	−21	−20	0	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	0	0	0	0	0	0	0	0	0	0	0	−1
13 000	+1	−23	−22	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+2	+2	0	0	0	0	0	0	0	0	0	0	−1	−1
14 000	+2	−25	−23	+1	+1	+1	+1	+1	+1	+1	+1	+1	+2	+2	+2	+2	0	0	0	0	0	0	0	0	−1	−1	−1	−1
15 000	+2	−27	−25	+1	+1	+1	+1	+1	+1	+1	+2	+2	+2	+2	+2	+2	0	0	0	0	0	0	0	0	−1	−1	−1	−1

The distance from the station to the middle of this zone is 132.8 km (=82.5 miles) and the curvature is 4500 feet.

REDUCTION TABLES FOR NUMBERED ZONES.

Zone 18.

[Unit of elevation 100 feet (27.1 fathoms for depths). $\theta=1^\circ\ 41'\ 13''$ to $1^\circ\ 29'\ 58''$. One compartment.]

Correction as read from map	Correction for departure from proportionality	Correction for elevation of station at—			Correction as read from map	Correction for departure from proportionality	Correction for elevation of station at—		
		5 000 feet	10 000 feet	15 000 feet			5 000 feet	10 000 feet	15 000 feet
+150	+1	−2	−5	−7	0	0	0	0	0
+125	+1	−2	−4	−6	− 25	0	0	+1	+1
+100	+1	−2	−3	−5	− 50	0	+1	+2	+2
+ 75	0	−1	−2	−3	− 75	0	+1	+2	+3
+ 50	0	−1	−2	−2	−100	0	+2	+3	+5
+ 25	0	0	−1	−1					

Zone 17.

[Unit of elevation 100 feet (27.1 fathoms for depths). $\theta=1^\circ\ 54'\ 52''$ to $1^\circ\ 41'\ 13''$. One compartment.]

+150	+3	−2	−4	−6	0	0	0	0	0
+125	+2	−2	−3	−5	− 25	0	+1	+1	+1
+100	+1	−1	−3	−4	− 50	0	+1	+1	+2
+ 75	+1	−1	−2	−3	− 75	+1	+1	+2	+3
+ 50	0	−1	−1	−2	−100	+1	+1	+3	+4
+ 25	0	−1	−1	−1					

Zone 16.

[Unit of elevation 100 feet (27.1 fathoms for depths). $\theta=2^\circ\ 11'\ 53''$ to $1^\circ\ 54'\ 52''$. One compartment.]

+150	+4	−2	−3	−5	0	0	0	0	0
+125	+3	−1	−3	−4	− 25	0	0	+1	+1
+100	+2	−1	−2	−3	− 50	0	+1	+1	+2
+ 75	+1	−1	−1	−2	− 75	+1	+1	+1	+2
+ 50	0	−1	−1	−2	−100	+1	+1	+2	+3
+ 25	0	0	−1	−1					

Zone 15.

[Unit of elevation 100 feet (27.1 fathoms for depths). $\theta=2^\circ\ 33'\ 46''$ to $2^\circ\ 11'\ 53''$. One compartment.]

+150	+5	−1	−3	−4	0	0	0	0	0
+125	+4	−1	−2	−3	− 25	0	0	0	+1
+100	+2	−1	−2	−3	− 50	0	0	+1	+1
+ 75	+1	−1	−1	−2	− 75	+1	+1	+1	+2
+ 50	+1	0	−1	−1	−100	+1	+1	+2	+3
+ 25	0	0	0	−1					

Zone 14.

[Unit of elevation 100 feet (27.1 fathoms for depths). $\theta=3^\circ\ 03'\ 05''$ to $2^\circ\ 33'\ 46''$. One compartment.]

+150	+6	−1	−2	−3	0	0	0	0	0
+125	+4	−1	−2	−3	− 25	0	0	0	0
+100	+3	−1	−1	−2	− 50	0	0	+1	+1
+ 75	+2	−1	−1	−2	− 75	+1	0	+1	+1
+ 50	+1	0	−1	−1	−100	+2	+1	+1	+2
+ 25	0	0	0	0					

Zone 13.

[Unit of elevation 1000 feet (271 fathoms for depths). θ=4° 19′ 13″ to 3° 03′ 05″. Sixteen compartments.]

No correction for elevation of station. No correction for departure from proportionality.

Zone 12.

[Unit of elevation 1000 feet (271 fathoms for depths). θ=5° 46′ 34″ to 4° 19′ 13″. Ten compartments.]

No correction for elevation of station. No correction for departure from proportionality.

Zone 11.

[Unit of elevation 1000 feet (271 fathoms for depths). θ=7° 51′ 30″ to 5° 46′ 34″. Eight compartments.]

No correction for elevation of station. No correction for departure from proportionality.

Zone 10.

[Unit of elevation 1000 feet (271 fathoms for depths). θ=10° 44′ to 7° 51′ 30″. Six compartments.]

No correction for elevation of station. No correction for departure from proportionality.

Zone 9.

[Unit of elevation 1000 feet (271 fathoms for depths). θ=14° 09′ to 10° 44′. Four compartments.]

No correction for elevation of station. No correction for departure from proportionality.

Zone 8.

[Unit of elevation 1000 feet (271 fathoms for depths). θ=20° 41′ to 14° 09′. Four compartments.]

No correction for elevation of station. No correction for departure from proportionality.

Zone 7.

[Unit of elevation 1000 feet (271 fathoms for depths). θ=26° 41′ to 20° 41′. Two compartments.]

No correction for elevation of station. No correction for departure from proportionality.

Zone 6.

[Unit of elevation 10 000 feet (2710 fathoms for depths). θ=35° 58′ to 26° 41′. Eighteen compartments.]

No correction for elevation of station. No correction for departure from proportionality.

Zone 5.

[Unit of elevation 10 000 feet (2710 fathoms for depths). θ=51° 04′ to 35° 58′. Sixteen compartments.]

No correction for elevation of station. No correction for departure from proportionality.

Zone 4.

[Unit of elevation 10 000 feet (2710 fathoms for depths). θ=72° 13′ to 51° 04′. Twelve compartments.]

No correction for elevation of station. No correction for departure from proportionality.

Zone 3.

[Unit of elevation 10 000 feet (2710 fathoms for depths). θ=105° 48′ to 72° 13′. Ten compartments.]

No correction for elevation of station. No correction for departure from proportionality.

Zone 2.

[Unit of elevation 10 000 feet (2710 fathoms for depths). θ=150° 56′ to 105° 48′. Six compartments.]

No correction for elevation of station. No correction for departure from proportionality.

Zone 1.

[Unit of elevation 10 000 feet (2710 fathoms for depths). θ=180° to 150° 56′. One compartment only.]

No correction for elevation of station. No correction for departure from proportionality.

SPECIAL REDUCTION TABLES FOR SEA STATIONS.

[Corrections in dynes in units of the fourth decimal place. Station at sea level.]

Depth	Zones														
Fathoms	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
5 000	−1	−11	−27	−39	−53	−55	−48	−40	−40	−34	−18	−3	+41	+51	+32
4 800	−1	−11	−27	−39	−53	−55	−47	−39	−38	−32	−17	−2	+41	+49	+31
4 600	−1	−11	−27	−39	−53	−54	−46	−37	−36	−29	−15	−1	+40	+47	+29
4 400	−1	−11	−27	−38	−53	−54	−45	−36	−34	−27	−14	−1	+40	+45	+28
4 200	−1	−11	−27	−38	−53	−53	−44	−34	−32	−25	−12	0	+39	+44	+27
4 000	−1	−11	−27	−38	−52	−52	−43	−33	−30	−23	−11	+1	+39	+42	+26
3 800	−1	−11	−27	−38	−51	−51	−42	−31	−28	−21	− 9	+1	+38	+40	+24
3 600	−1	−11	−27	−38	−51	−50	−41	−29	−26	−19	− 8	+2	+37	+38	+23
3 400	−1	−11	−26	−37	−50	−49	−39	−28	−24	−17	− 7	+2	+36	+36	+22
3 200	−1	−11	−26	−37	−49	−48	−38	−26	−22	−15	− 5	+3	+35	+34	+21
3 000	−1	−11	−26	−37	−48	−46	−36	−24	−20	−13	− 4	+3	+33	+32	+19
2 800	−1	−11	−26	−37	−47	−44	−34	−23	−18	−11	− 3	+4	+32	+30	+18
2 600	−1	−11	−26	−36	−46	−43	−32	−21	−16	−10	− 2	+4	+30	+28	+17
2 400	−1	−11	−26	−36	−44	−41	−30	−20	−14	− 8	− 1	+4	+28	+26	+15
2 200	−1	−11	−26	−35	−43	−39	−27	−17	−12	− 6	− 1	+4	+26	+24	+14
2 000	−1	−10	−26	−35	−42	−37	−25	−15	−11	− 5	0	+4	+25	+22	+12
1 800	−1	−10	−26	−34	−41	−34	−22	−13	− 9	− 4	0	+4	+23	+20	+12
1 600	−1	−10	−25	−34	−40	−32	−19	−10	− 7	− 2	+ 1	+4	+20	+18	+10
1 400	−1	−10	−25	−34	−38	−28	−16	− 9	− 5	− 2	+ 1	+4	+19	+16	+ 9
1 200	−1	−10	−25	−33	−35	−25	−13	− 7	− 3	− 1	+ 1	+3	+17	+14	+ 8
1 000	−1	−10	−25	−31	−31	−20	−10	− 5	− 2	0	+ 1	+2	+14	+12	+ 6
800	−1	−10	−25	−30	−27	−15	− 7	− 3	− 1	0	+ 1	+2	+11	+ 9	+ 5
600	−1	−10	−23	−26	*−21	−10	− 4	− 1	− 1	+ 1	+ 1	+2	+ 9	+ 7	+ 4
400	−1	−10	−22	−21	*−13	*− 5	− 2	− 1	0	+ 1	+ 1	+1	+ 6	+ 5	+ 2
200	−1	*−10	*−17	*−11	*− 4	*− 1	0	0	0	+ 1	+ 1	+1	+ 3	+ 2	+ 1
0	0	*0	*0	*0	*0	*0	0	0	0	0	0	0	0	0	0

* Use table following for these values on account of large second difference.

Supplementary table for use in connection with gravity stations at sea.

[Correction in dynes in units of the fourth decimal place. Station at sea level.]

Depth	Zone				
Fathoms	B	C	D	E	F
800		−25		−27	
750		−24		−26	
700		−24		−24	
650		−24		−22	
600		−23	−26	−21	−10
550		−23	−26	−19	− 9
500		−23	−25	−17	− 7
450		−23	−23	−15	− 6
400		−22	−21	−13	− 5
350		−21	−19	−11	− 4
300		−20	−17	− 9	− 3
250		−19	−14	− 6	− 2
200	−10	−17	−11	− 4	− 1
150	−10	−15	− 7	− 2	− 1
100	− 9	−11	− 4	− 1	0
75	− 8	− 9	− 2	− 1	0
50	− 7	− 5	− 1	− 1	0
25	− 5	− 1	− 1	0	0
10	− 2	0	0	0	0
0	0	0	0	0	0

USE OF TEMPLATES.

For each scale of map or chart to be used in the computations there was prepared a sheet of transparent celluloid with the circles and radial lines which define the limits of the zones and compartments drawn to the same scale.

Such a template is shown in illustration No. 10*a* as used for maps on a scale of 1/10000. The zones are marked with their designating letters, and the scale of the template is ordinarily marked on each. No attempt has been made to reproduce the illustration to the proper scale.

Each template consists of a sheet similar to that indicated in illustration No. 10*a* carrying lines bounding the compartments which lie on one side of the reference line. By turning the template 180° in azimuth on a map it serves also to fix the position of the remaining compartments. While in use the template is placed on a map with the center of the circles at the station and with the reference line lying in the meridian. As a convenient designation the compartments in any zone are numbered in the clockwise direction commencing with the first which is to the eastward of north from the station.

Illustration No. 10*b* shows a template such as was used on maps on a scale of 1/6013500. This necessarily shows more distant zones than illustration No. 10*a*. The dotted radial lines in zones 14 to 18 are not compartment boundaries. Each of these zones has one compartment only. They are lines dividing each of the zones into ten equal parts, as it was found convenient in estimating the mean elevation for such large zones to make separate estimates for each part rather than to make an estimate at once for the whole compartment or zone. For the same purpose dotted lines are shown in zone 7 separating each of its two compartments into five equal parts.

By the use of these transparent (celluloid) templates the many circles and radial lines fixing the limits of the zones and compartments on a given map for any station were superposed on the map by the mere process of laying the template on the map in the proper position. The use of the templates saved a very large amount of labor which would otherwise have been necessary in drawing the many zones and compartments on several hundred maps. It also left the maps without damage or defacement.

In computing the correction for topography and isostatic compensation for a given station the computer places the appropriate template in the proper position on the best contour map available. He then estimates the mean elevation of the surface in each compartment from the contour lines on the map, seen through the template, and at once takes out from the reduction tables the two corrections for that compartment and records them in the proper places on the computation forms. As he has the reduction tables constantly before him he is continually guided as to the accuracy with which the estimate of mean elevations must be made in order to secure the corrections with the required degree of accuracy. As a rule this estimate may be made very quickly, for as indicated in the reduction tables, an approximate elevation of a compartment is sufficient. This is especially true in the numbered zones 13 to 1, for which the unit elevations are either 1000 or 10 000 feet.

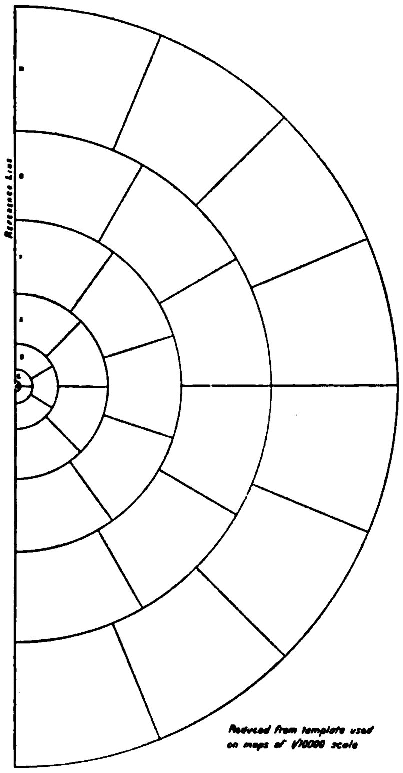

ILLUSTRATION No. 10 (a).—Template for maps of scale 1/10000 (reduced).

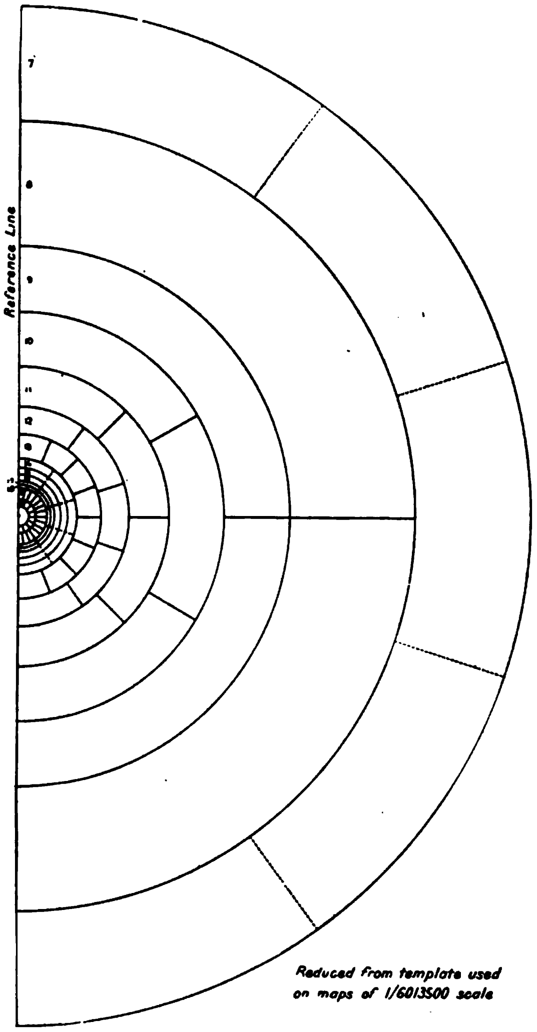

ILLUSTRATION No. 10 (b).—Template for maps of scale 1/6013500 (reduced).

EXAMPLES OF COMPUTATIONS OF CORRECTIONS.

The following table is a sample of the computations, and in it are given the values (in units of the fourth decimal place in dynes) of the correction for topography and isostatic compensation for each compartment of zones A to 1 at the San Francisco gravity station. This station is near the open coast, is 85 miles from the 1000-fathom line, and is only 375 feet above sea level.

San Francisco, Cal., gravity station No. 54.

[ϕ=37° 47′ 22″. λ=122° 25′ 40″. Elevation=375 feet.]

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
+2 0	+13 −1 +13 −1 +13 −1 +13 −1	+8 0 +9 0 +9 0 +9 0	+1 +1 +1 +1 +2 +1 +2 +1 +2 +1 +1 +1	0 0 +1 0 0 0 0 0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 −1 0 0 0 0 0 0 0 0 0 0 0 −1 0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 − 1 0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 − 1 0 − 1 0 − 1 0 0 0 − 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 − 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 − 1 0 0 0 − 1 0 0 0 0 0 0 0	0 0 0 0 − 4 0 − 4 0 − 1 0 0 0 0 0 − 3 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 − 2 0 0 0 0 0 0 0	− 2 0 0 0 0 0 0 0 − 2 0 − 3 0 − 3 0 − 1 0 0 0 + 2 0 + 2 0 +10 0 +10 0 + 4 0 + 1 0 − 1 0 0 0 − 2 0	− 1 0 0 0 0 0 0 0 0 0 − 1 0 − 1 0 0 0 0 0 − 2 0 − 2 0 0 0 0 0 0 0 0 0 + 2 0 + 8 0 +11 0 +12 0 +13 0 +13 0 +13 0 +13 0 +12 0 + 9 0 + 6 0 + 1 0 − 2 0 − 3 0 − 2 0
+2 0 +2	+52 −4 +48	+35 0 +35	+9 +6 +15	+1 0 +1	0 0 0	0 0 0	0 0 0	0 0 0	−2 0 −2	−1 0 −1	−7 0 −7	−14 0 − 14	+15 0 +15	+99 9 +99

18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
−4 0 +28 0	−7 0 +28 0	−12 0 +32 0	−16 0 +35 0	−21 0 +38 0	− 5 − 5 − 6 − 6 − 7 − 3 0 − 2 + 5 + 8 + 9 + 10 + 10 + 9 + 8 + 4 − 4 0	− 6 − 6 − 6 − 3 + 5 + 9 +11 +11 + 7 − 1 + 2	− 5 − 6 − 4 0 + 5 + 8 +10 + 9 0 + 4	− 5 − 6 − 1 + 4 + 8 +10 0 + 4	− 7 − 2 + 2 +10 0 + 7	− 2 − 2 + 3 + 9 0 + 7	0 + 1 0 + 9	0 0 0 0 0 0 0 0 0 0 0 0 0 0 +1 +1 +1 +1 +1 +1 +1 +1 +1 0 0 0 0	0 0 0 0 0 0 +1 0 0 0 +1 +1 +1 +1 +1 +1 +1 +1 0 0	0 0 +1 +1 0 +1 0 0 +1 +1 +1 +1 +1 0 0 0 0	0 0 0 0 0 0 0 +1 +1 +1. +1 +1 0 0	0 0 0 +1 0 +1 +1 +1 0 0	0 +1
+24 0 +24	+21 0 +21	+20 0 +20	+19 0 +19	+17 0 +17	+25	+23	+21	+14	+10	+15	+10	+9	+9	+8	+5	+4	+1

Sum of all zones =+446.

At the top of the table are given the latitude, longitude, and elevation of the station. In actual practice the zones may be arranged in any convenient manner on a single sheet. Here they are placed in such a way as to show them in as compact a form as possible.

The headings of the several columns indicate the zones by letter or number, it being understood that the zones are in the order of their distances from the station, namely, A to O, and 18 to 1, the zone A being at the station with its inner radius zero.

In a zone having more than one compartment, the compartments are numbered clockwise, the first one being to the north of the station and just to the east of the meridian passing through the station. Having this arrangement of compartments in mind, one can readily see in the table for any station the effect of the different prominent topographic features. This is noticeable in zone O for both the San Francisco and Pikes Peak gravity stations.

At San Francisco for the first 13 compartments of zone O the corrections are all zero or negative. These are all land compartments. In compartment 14, nearly due south from the station, a positive correction, due to the ocean, first appears. In compartments 15 to 25, all to the westward of the station, the corrections are all positive, showing the influence of the deep waters of the Pacific. Compartments 26 to 28 are land compartments, showing the influence of the Coast Range to the northwestward of San Francisco. The similar influence of the part of the Coast Range to the southeastward of San Francisco lying within this zone is shown in compartments 10 and 11.

It will be noticed that there is a double column for each of the zones B to O. The first column gives the effect on the intensity of gravity at the station, due to the topography and the isostatic compensation of the several compartments based upon the assumption that the station is, in each case, at the same elevation as the compartment. The mean elevation of the compartment is obtained from the map or maps used. Entering the table for the particular zone with this elevation, this correction is obtained from the fourth column, which is headed "Correction for topography and compensation." In the second column for zones B to O is given the effect of the intensity of gravity due to the elevation of the station above or below the average elevation of each compartment. These quantities are given in the tables under the headings "Correction for elevation of station above compartment" and "Correction for elevation of station below compartment."

In taking out the second correction it must be kept in mind, as already noted on pages 22 and 29, that it does not become zero in zones M, N, and O when the station is at the same elevation as the compartment, but, instead, has the values shown in the special column in the reduction tables for these zones. For zones B to L the second correction is zero when the station is at the same elevation as the compartment.

Two columns are given for each zone 18 to 14, the first one showing the correction as read from the map and given in the first columns of the reduction tables for those zones, while the second column contains the algebraic sum of the corrections for the departure from proportionality and for the elevation of the station above sea level.

For each of the zones 13 to 1, there is only one column of figures, which are the corrections for the compartments as read from the map, each compartment of zones 13 to 7 having a correction of 0.0001 dyne for each 1000 feet in elevation (271 fathoms for depth), and zones 6 to 1 having a correction of 0.0001 dyne for each 10 000 feet of elevation (2710 fathoms for depth).

The algebraic sums for each column is given at the foot of the column and immediately below these separate sums is given the algebraic sum for the zone. The sum for all zones is +446 in the units used in the computation or +0.0446 dynes. This is the correction at San Francisco for the topography of the entire earth and its compensation.

It was found at times to be desirable to treat in two parts the corrections for a compartment which contained both land and water areas. The corrections for land and water for the compartments treated in this way are connected in the table by brackets, the first number being for the land portion and the second for the water portion of the compartment in question. In determining the correction for any portion of a compartment the table is entered with the elevation of that portion as the argument as if it were the elevation of the whole compartment, but the correction entered in the computations is only that proportion of the total correction which the area of the portion of the compartment bears to its total area.

The elevations close to the gravity station at San Francisco are low and in no case inside of zone L is the height of a single compartment more than 700 feet above sea level. In zone L one compartment to the eastward of San Francisco, in the Coast Range, has an average elevation of about 800 feet. Zone L is just beyond the change of sign due to distance (see p. 65), and therefore the correction for that compartment is not over 0.0001 dyne. In zone M there are several compartments near the compartments of zone L in the Coast Range, already referred to, with elevations of about 1000 feet, each of which causes corrections of −0.0004 dyne (see third and fourth numbers in the column for zone M). In zone N there are two compartments having depths of about 900 fathoms, which cause corrections of +0.0010 dyne. The land compartments in this zone do not have elevations above 1000 feet. A portion of zone O extends well beyond the 1000-fathom line, which causes corrections as large as +0.0013 dyne for several water compartments.

The corrections for the land and water portions of each of the zones 18 to 14 are given separately, the correction being minus for the land and plus for the water. Most of the water sections of these zones are far out in the Pacific Ocean. Each of these zones has only one compartment, but for convenience in reading elevations and depths from the maps, each zone is divided into 10 parts and for each part the correction is taken from the reduction tables as one-tenth of the value given for the whole zone for an elevation equal to that of the part in question. The table was entered only once to obtain for the zone the correction for the elevation of the station above sea level. For each of the zones 18 to 14 at San Francisco the algebraic sum of the corrections for departure from proportionality and for elevation of station is zero.

Each of the zones 13 to 1 has only one column of figures in the table, as there are no corrections for elevation of station nor for departure from proportionality. The total correction for each of these zones is plus, showing that the effect of the water compartments predominates. There was no interpolation of values in any of the zones for the gravity station at San Francisco. All values were computed directly from the maps and charts.

The following table gives in detail the computation of the effect of topography and its isostatic compensation at the gravity station Pikes Peak, which is a mountain station far from the ocean. The station is much above the general elevation of the surrounding country.

Pikes Peak, Colo., Gravity Station No. 43.

[ϕ=38° 50′ 18″. λ=105° 02′ 00″. Elevation=14 085 feet.]

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
+2 0	+18 0	+42 −4	+57 −6	+70 −8	+58 −2	+35 +6	+19 +7	+11 +9	+3 +10	−2 +6	−6 +3	−28 +7	−18 +2	−9 +1
	+18 0	+42 −3	+57 −11	+70 −9	+59 −2	+35 +6	+18 +8	+9 +11	+3 +10	−2 +5	−6 +4	−27 +7	−20 +2	−9 +1
	+18 0	+42 0	+57 −8	+70 −11	+58 −2	+35 +6	+19 +7	+9 +10	+2 +10	−2 +6	−5 +4	−27 +7	−20 +2	−9 +1
	+18 0	+42 −4	+58 −3	+71 −4	+60 −1	+35 +6	+19 +7	+9 +10	+2 +10	−2 +6	−5 +5	−24 +7	−20 +2	−9 +1
			+58 −2	+71 −2	+61 +1	+38 +5	+19 +7	+9 +10	+3 +9	−2 +6	−4 +5	−20 +6	−18 +2	−10 +1
			+57 −4	+71 −3	+61 +1	+38 +5	+20 +7	+10 +10	+4 +9	−2 +6	−4 +5	−21 +7	−18 +2	−10 +1
				+72 0	+61 0	+40 +4	+22 +6	+12 +9	+7 +6	−2 +7	−4 +4	−21 +6	−16 +2	−9 +1
				+70 −8	+62 +1	+38 +5	+22 +6	+15 +6	+6 +7	−1 +6	−4 +4	−23 +7	−18 +2	−9 +1
					+63 +1	+39 +4	+25 +4	+14 +8	+5 +8	−2 +6	−5 +4	−27 +6	−26 +2	−8 +1
					+61 0	+40 +4	+24 +5	+15 +6	+6 +8	−2 +6	−5 +4	−32 +6	−27 +2	−8 +1
						+41 +4	+23 +5	+15 +7	+5 +8	−2 +6	−6 +4	−33 +5	−25 +2	−8 +1
						+38 +5	+25 +5	+14 +7	+4 +8	−1 +5	−5 +4	−33 +6	−27 +2	−9 +1
							+26 +4	+13 +8	+3 +9	−2 +6	−6 +4	−34 +7	−30 +2	−10 +1
							+26 +3	+13 +8	+4 +8	−2 +6	−6 +3	−30 +6	−30 +2	−12 +1
							+23 +5	+12 +8	+4 +8	−2 +6	−5 +4		−31 +2	−14 +1
							+21 +6	+12 +9	+4 +8	−2 +5	−5 +4		−22 +2	−15 +1
								+13 +8		−2 +6	−6 +4			−14 +1
								+14 +8		−2 +5	−6 +4			−14 +1
								+12 +9		−2 +6	−6 +4			−17 +1
								+11 +9		−2 +6	−6 +4			−17 +1
											−6 +4			−19 +1
											−6 +4			−19 +1
											−6 +4			−19 +1
											−6 +4			−17 +1
														−17 +1
														−18 +1
														−17 +1
														−11 +1
+2 0 +2	+72 0 +72	+168 −11 +157	+344 −34 +310	+565 −45 +520	+605 −3 +602	+452 +60 +512	+351 +92 +443	+242 +170 +412	+65 +136 +201	−38 +117 +79	−129 +97 −32	−380 +90 −290	−366 +32 −334	−357 +28 −329

18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
−71 +3	−71 +3	−71 +3	−66 +2	−60 +1	....	....	....	....	....	....	....	....	....	....	....	....	....
					....	....	....	....	....	....	....	....	....	....	....	....	
					....	....	....	....	....	....		....	....	....	....	....	
					....	....	....	....	....	....		....	....	....	....	....	
					....	....	....	....	....			....	....	....	....	....	
					....	....	....	....	....			....	....	....	....	....	
					....	....	....	....				....	....	....	....		
					....	....	....	....				....	....	....	....		
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												....					
												....					
−71 +3 −68	−71 +3 −68	−71 +3 −68	−66 +2 −64	−60 +1 −59	*−83*	*−48*	*−30*	*−17*	*0*	*+9*	*+7*	*+9*	*+9*	*+8*	*+5*	*+3*	*+1*

Sum of all zones = +1871.

NOTE.—Values shown in italics were obtained by interpolation from gravity stations Nos. 42, 44, and 45, at Colorado Springs, Denver, and Gunnison, Colo., respectively.

The arrangement of this table is the same as that for the station at San Francisco, which was discussed in detail. The corrections for the zones A to 14, at Pikes Peak, were computed from the elevations read from maps. For zones 13 to 1 they were interpolated (in the manner explained later under the heading "Saving of time by interpolation") from stations Nos. 42, 44, and 45, which are at Colorado Springs, Denver, and Gunnison, Colo., respectively. The total value of the effect of the topography and its isostatic compensation as obtained by the interpolation is given in the table for each of the zones 13 to 1. The leaders shown in the columns for these zones indicate the number of compartments in each zone.

As Pikes Peak is an inland station, there are no water compartments within the computed zones A to 14.

As was the case in the table showing the corrections for the different zones at the San Francisco gravity station, zones B to 14 at Pikes Peak have two columns of figures each. In each zone the first column shows the effect of the topography and compensation with the station at the same elevation as the several compartments, while the second column of figures shows the corrections due to the elevation of the station above or below the compartment.

It is interesting to notice the change of sign at zone F of the correction for elevation of station (see p. 52), the change of sign due to distance between zones J and K, in the first column for these zones, also the change in the sign of the total correction between zones K and L.

Pikes Peak is a conical-shaped mountain, which accounts for the corrections for the several compartments of each of the near-by zones being of about the same size. The effect of the mountains to the westward is clearly shown in zones M, N, and O, but especially in zone O, the corrections being larger in the lower half of each column corresponding to compartments west of the station than in the upper half of the column in each of these zones.

CORRECTIONS FOR TOPOGRAPHY AND ISOSTATIC COMPENSATION, SEPARATE ZONES.

In the following table are given the total corrections for each zone, for topography and its isostatic compensation, to the intensity of gravity at each of the 89 gravity stations used in this investigation. There is also given the total correction for each station, this necessarily being the sum of the corrections for the separate zones. The values are given in units of the fourth decimal place in dynes.

The names and numbers of the stations are given in the headings of the table, while the letters or numbers of the zones are shown in the first column. The value for each zone at a station was obtained from the computations of the corrections for the separate compartments of the zones. Samples of such computations made at a station are given in tables on pages 49 and 52 for the gravity stations at San Francisco and on Pikes Peak.

The figures in italics represent the accepted interpolated values for the correction for topography and its compensation as explained on pages 58–60. The other figures are the values for the zones for which the corrections were obtained directly from maps and the reduction tables.

Correction for topography and isostatic compensation, separate zones

Zone	Key West, No. 1	West Palm Beach, No. 2	Punta Gorda, No. 3	Apalachicola, No. 4	New Orleans, No. 5	Rayville, No. 6	Galveston, No. 7	Point Isabel, No. 8	Laredo, No. 9	Austin Capitol, No. 10
A	+ 1	+ 2	+ 1	+ 2	+ 1	+ 2	+ 2	+ 2	+ 2	+ 2
B	0	0	0	0	0	+20	0	+ 4	+ 56	+56
C	− 1	0	0	0	0	+ 4	0	0	+ 50	+64
D	0	0	0	0	0	+ 6	0	0	+ 21	+34
E	0	0	0	0	0	0	0	0	+ 8	+15
F	0	0	0	0	0	0	0	0	0	+ 2
G	0	0	0	0	0	0	0	0	0	0
H	0	0	0	0	0	0	0	0	0	0
I	0	0	0	0	0	0	0	0	0	0
J	0	0	0	0	0	0	0	0	0	−*14*
K	0	0	0	0	0	0	0	0	− 4	−*18*
L	0	+ 5	0	0	0	0	0	0	−10	−*22*
M	+ 14	+ 20	0	0	0	0	0	0	−24	−*41*
N	+ 42	+ 24	0	0	0	0	0	− 1	−26	−*43*
O	+ 55	+ 16	0	+ 6	0	0	0	+ 27	−21	−*44*
18	+ 8	+ 4	0	+ 2	+ 2	− 1	0	+ 10	− 5	− *8*
17	+ 4	+ 5	+ 1	+ 3	+ 2	− 1	+ 2	+ 12	− 6	− *8*
16	+ 3	+ 5	+ 2	+ 4	+ 5	− 1	+ 3	+ 13	− 7	− *7*
15	+ 5	+ 5	+ *6*	+ 9	+ 7	− 2	+ 4	+ 15	−10	− *7*
14	+ 8	+ 9	+ *10*	+ 11	+ 11	− 3	+ 6	+ 14	− 8	− *7*
13	+ 38	+ *33*	+ *30*	+ 17	+ 24	+ *5*	+ *6*	+ 12	−21	−*12*
12	+ 38	+ *39*	+ *31*	+ 11	+ 22	+ *5*	+ *4*	− 1	−10	− *9*
11	+ 42	+ *45*	+ *33*	+ 9	+ 7	*0*	− *2*	− 9	−12	− *7*
10	+ 25	+ *27*	+ *22*	+ 14	+ 3	− *1*	− *5*	− 5	− 4	−*11*
9	+ 15	+ *15*	+ *14*	+ 12	− 2	− *3*	+ *1*	+ 5	+ 4	+ *1*
8	+ 15	+ *15*	+ *13*	+ 10	+ 5	+ *3*	+ *7*	+ 9	+10	+ *7*
7	+ 5	+ *5*	+ *5*	+ *6*	+ 7	+ *8*	+ *8*	+ 9	+ *9*	+ *9*
6	+ 6	+ *5*	+ *6*	+ *8*	+ 10	+ *9*	+*10*	+ 10	+*10*	+*10*
5	+ 10	+ *10*	+ *10*	+ *10*	+ *10*	+*11*	+*10*	+ 10	+*10*	+*10*
4	+ 8	+ *8*	+ *8*	+ 7	+ *8*	+ 7	+ *9*	+ 9	+ *9*	+ *9*
3	+ 6	+ *6*	+ *6*	+ *6*	+ *6*	+ *5*	+ *6*	+ 6	+ *6*	+ *6*
2	+ 2	+ *2*	+ *2*	+ *3*	+ *3*	+ *3*	+ *2*	+ 2	+ *2*	+ *2*
1	+ 1	+ *1*	+ *1*	+ *1*	+ *1*	+ *1*	+ *1*	+ 1	+ *1*	+ *1*
Total	+322	+306	+201	+151	+132	+77	+74	+154	+30	−30

Zone	Austin, University, No. 11	McAlester, No. 12	Little Rock, No. 13	Columbia, No. 14	Atlanta, No. 15	McCormick, No. 16	Charleston, No. 17	Beaufort, No. 18	Charlottesville, No. 19	Deer Park, No. 20
A	+ 2	+ 2	+ 2	+ 2	+ 2	+ 2	+ 2	+ 1	+ 2	+ 2
B	+56	+60	+48	+60	+ 64	+ 56	+ 4	0	+56	+ 68
C	+72	+87	+31	+78	+104	+ 64	0	0	+62	+144
D	+40	+52	+12	+48	+ 90	+ 30	0	0	+33	+209
E	+16	+21	+ 5	+19	+ 40	+ 13	0	0	+11	+178
F	+ 6	+10	0	+ 7	+ 19	0	0	0	+ 3	+ 91
G	0	0	0	0	0	0	0	0	0	+ 40
H	0	0	0	0	0	0	0	0	0	+ 20
I	0	0	0	0	0	0	0	0	0	0
J	−14	−13	0	−12	− 16	− 2	0	0	− 7	− 16
K	−18	−16	− 1	−16	− 20	− 5	0	0	−11	− 36
L	−22	−22	0	−17	− 24	− 7	0	0	−21	− 59
M	−41	−46	−20	−34	− 50	− 28	0	0	−52	− 97
N	−43	−35	−30	−39	− 44	− 31	− 1	+ 4	−46	− 79
O	−44	−40	−29	−42	− 49	− 37	+ 2	+ 45	−52	− 72
18	− 8	− 8	− 5	− 7	− 9	− 7	+ 2	+ 14	−10	− 11
17	− 8	− 8	− 5	− 7	− 10	− 8	+ 2	+ 16	− 9	− 10
16	− 7	− 9	− 5	− 6	− 9	− 8	+ 2	+ 20	− 8	− 10
15	− 7	− 9	− 5	− 6	− *7*	− *3*	+ 3	+ 27	− 7	− *8*
14	− 7	− 9	− 5	− 7	− 6	− *3*	+ 4	+ 34	− 7	− *8*
13	−12	−15	− 8	−*10*	− 7	− *1*	+ 12	+ 52	−10	− *11*
12	− 9	−13	− 7	− *5*	− 1	+ *7*	+ 21	+ 36	+ 8	+ *2*
11	− 7	−12	− 5	*0*	+ 6	+ *13*	+ 24	+ 29	+13	+ *7*
10	−11	−*12*	− 2	+ *6*	+ 14	+ *17*	+ 21	+ 19	+18	+ *13*
9	+ *1*	− *4*	− 5	+ *3*	+ 9	+ *10*	+ *12*	+ 14	+12	+ *10*
8	+ *7*	+ *2*	+ *2*	+ *4*	+ 6	+ *8*	+ *12*	+ *14*	+*11*	+ *10*
7	+ *9*	+ *8*	+ *8*	+ *6*	+ *6*	+ *6*	+ *5*	+ *5*	+ *5*	+ *5*
6	+*10*	+ *9*	+ *9*	+ *7*	+ *7*	+ *7*	+ *6*	+ *6*	+ *6*	+ *6*
5	+*10*	+*11*	+*11*	+*10*	+ *10*	+ *10*	+ *9*	+ *8*	+ *8*	+ *8*
4	+ *9*	+ *8*	+ *7*	+ *7*	+ *7*	+ *7*	+ *7*	+ *7*	+ *7*	+ *7*
3	+ *6*	+ *5*	+ *5*	+ *6*	+ *6*	+ *6*	+ *6*	+ *6*	+ *6*	+ *6*
2	+ *2*	+ *3*	+ *3*	+ *3*	+ *3*	+ *3*	+ *3*	+ *3*	+ *3*	+ *3*
1	+ *1*	+ *1*	+ *1*	+ *1*	+ *1*	+ *1*	+ *1*	+ *1*	+ *1*	+ *1*
Total	−11	+ 8	+12	+59	+142	+120	+159	+361	+25	+413

Correction for topography and isostatic compensation, separate zones—Continued.

Zone	Washington, C. & G. S. Office, No. 21	Washington, Smithsonian Institution, No. 22	Baltimore, No. 23	Philadelphia, No. 24	Princeton, No. 25	Hoboken, No. 26	New York, No. 27	Worcester, No. 28	Boston, No. 29	Cambridge, No. 30
A	+2	+2	+2	+2	+2	+2	+2	+2	+2	+2
B	+12	+8	+24	+12	+40	+8	+27	+56	+16	+12
C	+2	0	+4	+4	+16	0	+7	+64	+4	0
D	0	0	+6	0	+6	0	+2	+31	+1	0
E	0	0	0	0	0	0	0	+11	0	0
F	0	0	0	0	0	0	0	+7	0	0
G	0	0	0	0	0	0	0	0	0	0
H	0	0	0	0	0	0	0	0	0	0
I	0	0	0	0	0	0	0	0	0	0
J	0	0	−1	0	0	0	0	−10	0	−2
K	0	0	−2	0	0	0	0	−13	0	−3
L	0	0	−3	0	0	0	0	−14	0	−3
M	−12	−12	−20	−6	−11	−12	−12	−27	−4	−9
N	−17	−17	−16	−10	−16	−18	−18	−25	−12	−15
O	−23	−23	−20	−19	−22	−25	−26	−28	−10	−14
18	−5	−5	−6	−3	−4	−6	−6	−2	−2	−2
17	−8	−8	−7	−6	−6	−5	−5	−3	−1	−1
16	−9	−9	−9	−6	−5	−3	−3	−4	−1	−2
15	−8	−8	−8	−3	−1	+1	+1	−2	−2	−2
14	−4	−4	−3	0	+1	+3	+3	−2	−2	−2
13	+3	+3	+7	+12	+13	+14	+14	+9	+11	+10
12	+13	+13	+14	+19	+20	+22	+22	+24	+26	+25
11	+18	+18	+19	+21	+21	+21	+21	+23	+25	+25
10	+17	+17	+17	+16	+16	+16	+16	+17	+18	+18
9	+11	+11	+10	+11	+11	+11	+11	+12	+12	+12
8	+12	+12	+13	+14	+14	+15	+15	+17	+17	+17
7	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6
6	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6
5	+7	+7	+7	+6	+6	+6	+6	+6	+6	+6
4	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6
3	+6	+6	+6	+6	+6	+6	+6	+6	+6	+6
2	+4	+4	+4	+4	+4	+4	+4	+4	+4	+4
1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1
Total	+40	+34	+57	+93	+130	+79	+106	+178	+133	+101

Zone	Calais, No. 31	Ithaca, No. 32	Cleveland, No. 33	Cincinnati, No. 34	Terre Haute, No. 35	Chicago, No. 36	Madison, No. 37	St. Louis No. 38	Kansas City, No. 39	Ellsworth, No. 40
A	+2	+2	+2	+2	+2	+2	+2	+2	+2	+2
B	+25	+60	+58	+60	+56	+56	+62	+56	+64	+68
C	+4	+88	+78	+84	+60	+72	+95	+60	+97	+124
D	+4	+59	+48	+57	+28	+42	+70	+30	+72	+140
E	0	+27	+20	+22	+12	+16	+30	+13	+30	+82
F	0	+6	+10	0	+2	+4	+10	0	+16	+40
G	0	0	0	0	0	0	0	0	0	+12
H	0	0	0	0	0	0	0	0	0	0
I	0	0	0	0	0	0	0	0	0	0
J	0	−16	−16	−11	−8	−7	−16	−3	−16	−16
K	0	−20	−20	−17	−10	−9	−20	−12	−20	−20
L	0	−32	−24	−20	−12	−11	−24	−13	−24	−47
M	−5	−50	−42	−42	−30	−22	−57	−28	−53	−87
N	−4	−56	−41	−50	−37	−26	−48	−32	−47	−85
O	−15	−58	−45	−48	−35	−23	−49	−33	−55	−95
18	−3	−8	−9	−8	−6	−6	−7	−5	−10	−19
17	−3	−8	−10	−8	−6	−6	−7	−5	−10	−19
16	−3	−7	−10	−8	−6	−7	−8	−5	−10	−19
15	−4	−7	−11	−8	−6	−8	−8	−7	−11	−19
14	−3	−7	−11	−8	−7	−9	−9	−9	−11	−20
13	−3	−6	−18	−15	−16	−16	−16	−16	−20	−44
12	+9	+7	−10	−8	−9	−10	−10	−10	−13	−26
11	+18	+8	−5	−3	−7	−4	−3	−9	−14	−19
10	+18	+11	+4	+4	−2	−1	−2	−5	−14	−15
9	+13	+8	+5	+4	+1	+1	0	−2	−8	−4
8	+16	+12	+8	+6	+4	+6	+6	+2	−1	+3
7	+6	+6	+6	+6	+7	+7	+7	+7	+8	+7
6	+6	+6	+7	+7	+8	+8	+8	+8	+9	+9
5	+5	+7	+8	+9	+9	+9	+9	+10	+11	+10
4	+6	+6	+7	+7	+7	+7	+7	+7	+7	+8
3	+6	+6	+5	+5	+5	+5	+5	+5	+5	+5
2	+5	+4	+3	+3	+3	+3	+3	+3	+3	+3
1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1
Total	+101	+49	−2	+23	+6	+74	+31	+10	−12	−40

Correction for topography and isostatic compensation, separate zones—Continued.

Zone	Wallace, No. 41	Colorado Springs, No. 42	Pikes Peak, No. 43	Denver, No. 44	Gunnison, No. 45	Grand Junction, No. 46	Green River, No. 47	Pleasant Valley Junction, No. 48	Salt Lake City, No. 49	Grand Canyon, Wyo., No. 50
A	+2	+2	+2	+2	+2	+2	+2	+2	+2	+2
B	+68	+68	+72	+68	+68	+68	+68	+68	+68	+68
C	+152	+160	+157	+160	+164	+160	+156	+160	+156	+164
D	+246	+306	+310	+300	+324	+282	+270	+318	+276	+327
E	+248	+408	+520	+384	+472	+336	+302	+451	+325	+473
F	+140	+331	+602	+290	+430	+239	+199	+399	+216	+429
G	+72	+192	+512	+168	+285	+120	+97	+254	+109	+288
H	+32	+127	+443	+98	+202	+66	+56	+174	+59	+199
I	+20	+78	+412	+60	+130	+33	+27	+101	+19	+132
J	−16	−11	+201	0	+22	−7	−16	+4	−18	+25
K	−40	−71	+79	−40	−56	−65	−51	−49	−73	−39
L	−72	−147	−32	−98	−168	−132	−101	−142	−121	−125
M	−211	−369	−290	−362	−526	−391	−329	−378	−336	−420
N	−192	−342	−334	−376	−462	−374	−295	−343	−316	−389
O	−169	−339	−329	−346	−409	−349	−324	−315	−299	−308
18	−36	−68	−68	−68	−76	−74	−65	−59	−65	−57
17	−36	−69	−68	−67	−74	−73	−70	−61	−64	−60
16	−36	−69	−68	−67	−68	−72	−67	−63	−63	−61
15	−37	−68	−64	−64	−64	−*66*	−68	−64	−65	−60
14	−39	−62	−59	−63	−62	−*65*	−69	−65	−65	−54
13	−69	−81	−*83*	−84	−97	−*101*	−108	−*104*	−107	−86
12	−38	−48	−*48*	−48	−52	−*55*	−59	−*58*	−62	−51
11	−*25*	−30	−*30*	−30	−33	−*34*	−35	−*35*	−36	−38
10	−*16*	−*17*	−*17*	−*17*	−18	−*15*	−12	−*14*	−12	−22
9	−*2*	*0*	*0*	*0*	+2	+*3*	+4	+*4*	+5	−1
8	+*6*	+*9*	+*9*	+*9*	+11	+*11*	+11	+*11*	+11	+9
7	+*7*	+*7*	+*7*	+*7*	+*7*	+*7*	+*8*	+*7*	+*7*	+6
6	+*9*	+*9*	+*9*	+*9*	+*9*	+*9*	+*9*	+*9*	+*9*	+*8*
5	+*10*	+*9*	+*9*	+*10*	+*9*	+*9*	+*9*	+*9*	+*9*	+*8*
4	+*8*	+*8*	+*8*	+*8*	+*8*	+*8*	+*8*	+*8*	+*8*	+*7*
3	+*5*	+*5*	+*5*	+*5*	+*5*	+*5*	+*5*	+*5*	+*5*	+*4*
2	+*3*	+*3*	+*3*	+*3*	+*3*	+*3*	+*3*	+*3*	+*3*	+*3*
1	+*1*	+*1*	+*1*	+*1*	+*1*	+*1*	+*1*	+*1*	+*1*	+*1*
Total	−5	−68	+1871	−148	−11	−511	−434	+238	−414	+382

Zones	Norris Geyser Basin, No. 51	Lower Geyser Basin, No. 52	Seattle, University, No. 53	San Francisco, No. 54	Mount Hamilton, No. 55	Seattle High School, No. 56	Iron River, No. 57	Ely, No. 58	Pembina, No. 59	Mitchell, No. 60
A	+2	+2	+2	+2	+2	+2	+2	+2	+2	+2
B	+68	+68	+33	+48	+68	+44	+64	+64	+60	+64
C	+164	+160	+12	+35	+156	+18	+124	+124	+88	+116
D	+324	+318	+6	+15	+240	+10	+138	+138	+60	+123
E	+464	+459	+1	+1	+274	+3	+80	+80	+24	+65
F	+411	+403	0	0	+184	0	+40	+30	+10	+30
G	+264	+254	0	0	+92	0	+12	+12	0	+12
H	+184	+176	0	0	+53	0	0	0	0	0
I	+115	+107	0	0	+33	0	0	0	0	0
J	+17	+12	0	−2	+7	*0*	−16	−16	−16	−16
K	−46	−41	0	−1	−8	*0*	−20	−20	−20	−20
L	−124	−126	−1	−7	−18	−*1*	−42	−33	−24	−28
M	−409	−406	−19	−14	−24	−*19*	−84	−85	−52	−78
N	−381	−*379*	−95	+15	−16	−*95*	−63	−69	−52	−80
O	−*303*	−*299*	−90	+99	0	−*89*	−50	−67	−62	−89
18	−*56*	−*55*	−14	+24	+2	−*14*	−6	−12	−13	−18
17	−*59*	−*58*	−11	+21	−2	−*11*	−6	−12	−13	−18
16	−*60*	−*59*	−10	+20	0	−*10*	−6	−12	−13	−18
15	−*59*	−*58*	−10	+19	+2	−*10*	−7	−12	−13	−19
14	−*53*	−*52*	−11	+17	+8	−*11*	−7	−11	−14	−19
13	−*84*	−*83*	−21	+25	+22	−*21*	−18	−16	−25	−31
12	−*51*	−*49*	−18	+23	+19	−*18*	−12	−*13*	−14	−21
11	−*38*	−*37*	−8	+21	+20	−*8*	−9	−*11*	−13	−24
10	−*22*	−*21*	0	+14	+15	*0*	−7	−*10*	−15	−16
9	−*1*	−*1*	+4	+10	+*10*	+*4*	−*2*	−5	−8	−10
8	+*9*	+*9*	+10	+15	+*15*	+*10*	+*2*	−*1*	−5	−5
7	+*6*	+*6*	+6	+10	+*10*	+*6*	+*5*	+*5*	+4	+*6*
6	+*8*	+*8*	+7	+9	+*9*	+*7*	+*8*	+*9*	+10	+*9*
5	+*8*	+*8*	+8	+9	+*9*	+*8*	+*8*	+*9*	+10	+*11*
4	+*7*	+*7*	+7	+8	+*8*	+*7*	+*6*	+*6*	+7	+*7*
3	+*4*	+*4*	+3	+5	+*5*	+*3*	+*4*	+*4*	+3	+*4*
2	+*3*	+*3*	+3	+4	+*4*	+*3*	+*4*	+*4*	+4	+*3*
1	+*1*	+*1*	+1	+1	+*1*	+*1*	+*1*	+*1*	+1	+*1*
Total	+313	+281	−205	+446	+1200	−181	+143	+83	−89	−57

Correction for topography and isostatic compensation, separate zones—Continued.

Zones	Sweetwater, No. 61	Kerrville, No. 62	El Paso, No. 63	Nogales, No. 64	Yuma, No. 65	Compton, No. 66	Goldfield, No. 67	Yavapai, No. 68	Grand Canyon, Ariz., No. 69	Gallup, No. 70
A	+2	+2	+2	+2	+2	+2	+2	+2	+2	+2
B	+68	+68	+68	+68	+36	+16	+68	+68	+68	+68
C	+136	+128	+156	+156	+12	+4	+160	+122	+148	+160
D	+191	+151	+262	+264	+6	0	+295	+261	+185	+312
E	+148	+92	+284	+288	0	0	+394	+379	+174	+424
F	+69	+45	+177	+183	0	0	+308	+324	+82	+370
G	+25	+20	+86	+93	0	0	+171	+227	+21	+218
H	+16	+16	+45	+48	0	0	+115	+152	−12	+143
I	0	0	+20	+20	0	0	+61	+109	−41	+88
J	−16	−16	−16	−16	0	0	−11	+25	−46	+4
K	−24	−20	−40	−40	−6	0	−40	−26	−112	−45
L	−54	−48	−72	−72	−12	−5	−96	−107	−154	−121
M	−123	−107	−226	−162	−28	−25	−313	−294	−357	−383
N	−100	−76	−210	−150	−25	−50	−277	−289	−299	−343
O	−107	−64	−221	−148	−48	−60	−301	−256	−*256*	−312
18	−24	−12	−46	−30	−17	−10	−61	−56	−*56*	−63
17	−22	−12	−45	−24	−17	−8	−56	−53	−*53*	−63
16	−21	−11	−44	−24	−18	0	−51	−48	−*48*	−65
15	−22	−*13*	−48	−28	−18	+6	−41	−48	−*48*	−69
14	−22	−*12*	−49	−28	−20	+7	−40	−50	−*50*	−63
13	−38	−*23*	−75	−49	−15	+18	−61	−81	−*81*	−91
12	−*21*	−*13*	−32	−27	−9	+14	−20	−56	−*56*	−47
11	−*14*	−*11*	−23	−12	+3	+9	−4	−25	−*25*	−32
10	−*11*	−*8*	−7	0	+3	+13	+5	−4	−*4*	−*9*
9	+*2*	+*2*	+3	+6	+10	+11	+8	+6	+*6*	+*4*
8	+*8*	+*8*	+14	+15	+16	+16	+12	+12	+*12*	+*12*
7	+*9*	+*9*	+5	+*8*	+10	+11	+*9*	+8	+*8*	+7
6	+*10*	+*10*	+*10*	+*9*	+*9*	+*9*	+*9*	+*9*	+*9*	+*9*
5	+*10*	+*10*	+*10*	+*9*	+*9*	+*9*	+*9*	+*9*	+*9*	+*9*
4	+*9*	+*9*	+*9*	+*8*	+*8*	+*8*	+*8*	+*8*	+*8*	+*8*
3	+*6*	+*6*	+*6*	+*5*	+*5*	+*5*	+*5*	+*5*	+*5*	+*5*
2	+*2*	+*2*	+*3*	+*4*	+*4*	+*4*	+*4*	+*3*	+*3*	+*3*
1	+*1*	+*1*	+*1*	+*1*	+*1*	+*1*	+*1*	+*1*	+*1*	+*1*
Total	+92	+133	+7	+377	−102	+5	+272	+337	−957	+141

Zones	Las Vegas, No. 71	Shamrock, No. 72	Denison, No. 73	Minneapolis, No. 74	Lead, No. 75	Bismarck, No. 76	Hinsdale, No. 77	Sandpoint, No. 78	Boise, No. 79	Astoria, No. 80
A	+2	+2	+2	+2	+2	+2	+2	+2	+2	+1
B	+68	+68	+60	+60	+64	+68	+68	+68	+68	0
C	+160	+140	+84	+92	+160	+128	+140	+136	+148	0
D	+312	+198	+54	+64	+294	+156	+190	+186	+222	−5
E	+424	+160	+24	+24	+378	+98	+147	+140	+193	−1
F	+361	+80	+10	+10	+276	+44	+70	+63	+101	0
G	+217	+36	0	0	+158	+18	+26	+24	+48	0
H	+137	+16	0	0	+99	+6	+1	+10	+25	0
I	+88	0	0	0	+43	0	0	−5	−2	0
J	+6	−16	−16	−16	−3	−16	−16	−16	−14	0
K	−42	−27	−20	−20	−35	−20	−25	−43	−55	0
L	−128	−52	−24	−24	−88	−48	−54	−71	−85	−4
M	−377	−128	−37	−56	−233	−112	−149	−227	−223	−23
N	−329	−115	−42	−48	−199	−96	−145	−204	−227	+4
O	−297	−122	−45	−56	−174	−105	−135	−205	−233	+29
18	−62	−24	−9	−12	−36	−20	−31	−42	−53	+3
17	−62	−24	−9	−12	−37	−20	−31	−42	−56	0
16	−62	−24	−9	−12	−37	−19	−31	−40	−56	+3
15	−59	−24	−9	−13	−39	−20	−32	−40	−54	+5
14	−61	−25	−9	−13	−40	−20	−33	−40	−52	+3
13	−89	−44	−20	−*21*	−61	−38	−66	−70	−80	0
12	−43	−*25*	−*13*	−*15*	−*35*	−*26*	−40	−39	−57	−1
11	−26	−*17*	−*11*	−*12*	−*30*	−*23*	−30	−21	−24	+*3*
10	−18	−*14*	−*12*	−*9*	−*19*	−*17*	−21	−11	−8	+*6*
9	−1	−*1*	−*3*	−*5*	−*6*	−*10*	−13	0	+2	+*6*
8	+9	+*6*	+*3*	*0*	+*1*	−*3*	+2	+7	+9	+*11*
7	+7	+*8*	+*8*	+*6*	+*6*	+*5*	+5	+*6*	+*7*	+*7*
6	+*9*	+*10*	+*19*	+*9*	+*9*	+*9*	+10	+*8*	+*8*	+*7*
5	+*10*	+*10*	+*11*	+*10*	+*10*	+*10*	+*9*	+*8*	+*8*	+*8*
4	+*8*	+*9*	+*8*	+*6*	+*7*	+*7*	+*7*	+*7*	+*7*	+*7*
3	+*5*	+*6*	+*5*	+*4*	+*4*	+*4*	+*3*	+*3*	+*4*	+*3*
2	+*3*	+*2*	+*3*	+*4*	+*3*	+*3*	+*4*	+*3*	+*3*	+*3*
1	+*1*	+*1*	+*1*	+*1*	+*1*	+*1*	+*1*	+*1*	+*1*	+*1*
Total	+171	+70	−6	−52	+443	−54	−167	−444	−423	+76

Correction for topography and isostatic compensation, separate zones—Continued.

Zones	Sisson, No. 81	Rock Springs, No. 82	Paxton, No. 83	Washington, Bureau of Standards, No. 84	North Hero, No. 85	Lake Placid, No. 86	Potsdam, No. 87	Wilson, No. 88	Alpena, No. 89
A	+2	+2	+2	+2	+2	+2	+2	+2	+2
B	+68	+68	+68	+48	+24	+68	+56	+48	+56
C	+151	+160	+152	+32	+4	+136	+52	+28	+68
D	+253	+309	+240	+16	+6	+170	+22	+12	+42
E	+256	+417	+228	+8	0	+116	+8	+8	+16
F	+159	+350	+130	0	0	+52	0	0	0
G	+72	+210	+60	0	0	+25	0	0	0
H	+32	+129	+32	0	0	+15	0	0	0
I	−5	+86	0	0	0	−9	0	0	0
J	−32	+9	−16	−*1*	0	−16	−13	0	−16
K	−78	−40	−40	−*1*	0	−34	−17	0	−20
L	−103	−120	−72	−*2*	−3	−50	−18	−8	−24
M	−241	−350	−183	−*15*	−32	−75	−40	−20	−35
N	−205	−363	−170	−*19*	−44	−52	−47	−33	−36
O	−174	−371	−155	−*25*	−48	−41	−42	−46	−34
18	−29	−73	−33	−*5*	−10	−10	−8	−9	−7
17	−25	−71	−34	−*8*	−10	−9	−8	−10	−7
16	−21	−71	−33	−*9*	−11	−9	−9	−9	−7
15	−17	−73	−33	−*8*	−7	−*8*	−8	−*10*	−7
14	−7	−67	−33	−*4*	−7	−*7*	−9	−*10*	−8
13	−2	−99	−*59*	+*2*	−*16*	−*13*	−16	−*13*	−15
12	+8	−55	−*33*	+*13*	−*6*	−*3*	−*5*	−*3*	−10
11	+12	−38	−*26*	+18	+*3*	+*4*	+*1*	−*1*	−*5*
10	+9	−*16*	−*17*	+*17*	+*11*	+*11*	+*8*	+*5*	−*1*
9	+*8*	+*2*	−*4*	+*11*	+*10*	+*9*	+*7*	+*5*	+*1*
8	+*13*	+*10*	+*3*	+*12*	+*11*	+*11*	+*11*	+*10*	+*6*
7	+*9*	+*7*	+*7*	+*6*	+*6*	+*6*	+*7*	+*7*	+*6*
6	+*8*	+*9*	+*9*	+*6*	+*6*	+*6*	+*6*	+*6*	+*7*
5	+*9*	+*9*	+*10*	+*7*	+*7*	+*7*	+*6*	+*6*	+*7*
4	+*8*	+*8*	+*8*	+*6*	+*6*	+*6*	+*5*	+*5*	+*5*
3	+*4*	+*5*	+*5*	+*6*	+*6*	+*6*	+*6*	+*6*	+*5*
2	+*4*	+*3*	+*3*	+*4*	+*5*	+*5*	+*5*	+*5*	+*5*
1	+*1*	+*1*	+*1*	+*1*	+*1*	+*1*	+*1*	+*1*	+*1*
Total	+147	−13	+17	+118	−86	+320	−37	−18	−5

INTERPOLATION FOR OUTER ZONES.*

To compute the effect of topography and its isostatic compensation upon the intensity of gravity for all zones at all stations by the methods thus far described would be an unnecessary waste of time. Each figure in the table on pp. 54–58 is the value of the effect, on the intensity of gravity, of the topography and compensation of an entire zone. A comparison of the values for similar zones at any two stations comparatively near each other shows that the effect produced by corresponding zones tend to be more nearly the same for the two stations the larger the zone considered. If the comparison be extended to include several stations in a group it becomes evident that it is possible to obtain with considerable accuracy the effect for any large zone, for a station near the center of the group, by interpolation from the computed effects for that zone at surrounding stations near it.

For instance, the two values of each of zones 5 to 1 and zone 7 at Point Isabel (station No. 8) and at Kerrville (station No. 62) are identical, while the two values of each of zones 6 and 8 differ by only 0.0001 dyne. All the zones were computed at each of these two stations which are 476 kilometers (296 miles) apart.

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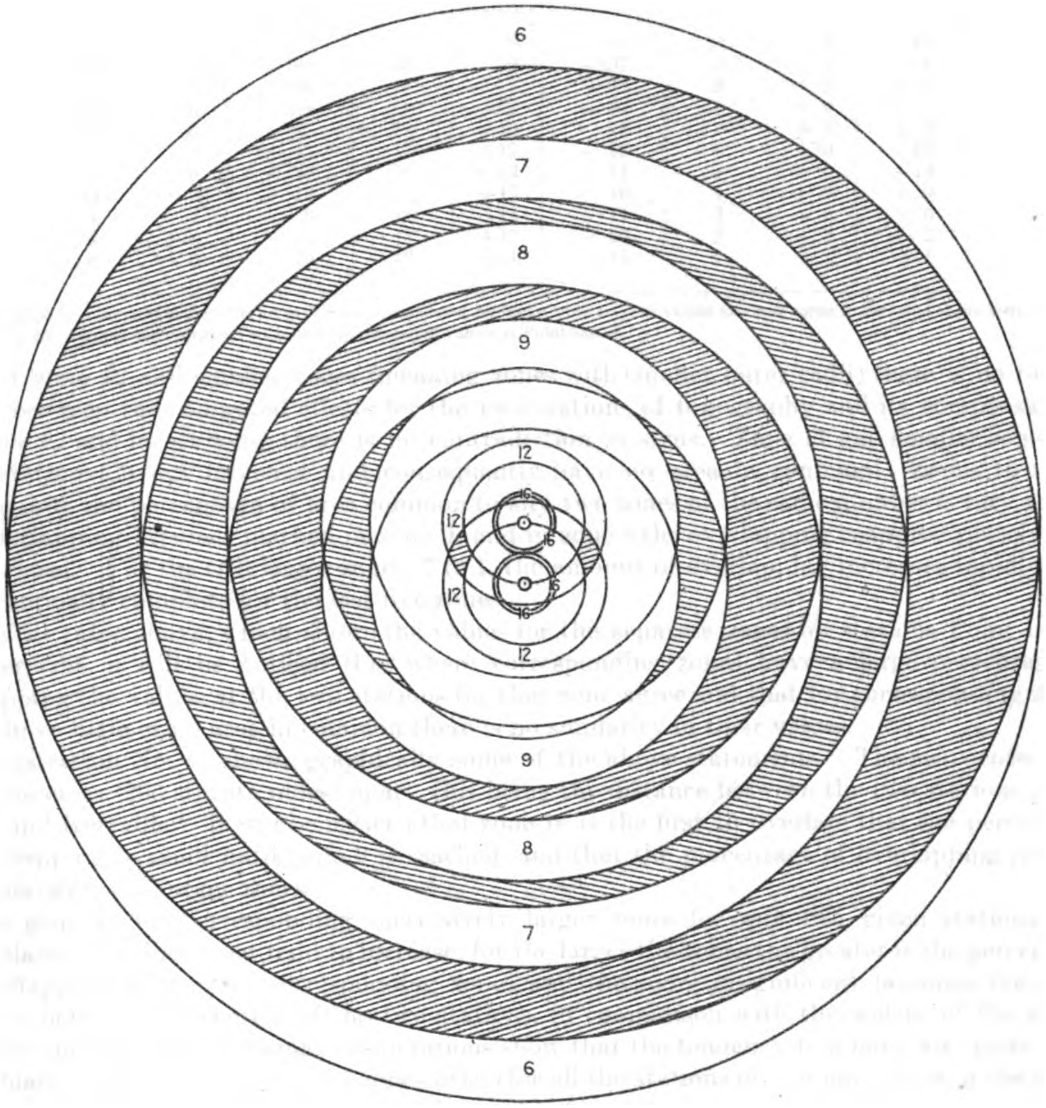
* Pp. 36 to 45 of The Figure of the Earth and Isostasy from Measurements in the United States, by John F. Hayford, contain in detail a description of the interpolation for outer zones of the effect of topography and its isostatic compensation upon the deflections of the plumb line.

ILLUSTRATION No. 11.


6
7
8
9
12
16
12
16
16
12
16
12
12
9
8
7
6

Showing overlaping of zones at two near stations.

The distance between centers is 296 statute miles, the same as that between Pt. Isabel and Kerrville, two stations which are referred to in the text under "Interpolation."

Scale
Degrees
0
5
10
15
20
25

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The same criteria of safety were applied to these cases as to the others in which only direct interpolations were involved. The cases of extrapolation most frequently occur at stations lying near the edge of the area covered by the investigation. The total number of such cases was small.

In the table of "Corrections for topography and isostatic compensation, separate zones," on pages 54–58, may be seen the extent of the agreement between values for corresponding zones at adjacent stations. This table also serves as an illustration of the amount of computation saved by interpolation. The interpolated values are shown in italics. For example, stations Nos. 1 to 11 are on or not very far from the Gulf of Mexico. Nos. 16 to 31 are on or close to the Atlantic coast. By consulting the table and illustration No. 13, which shows graphically the location of all the stations used in this investigation, other groups of adjacent stations may be found.

The following table will serve as an illustration of the degree of agreement between values for corresponding zones at adjacent stations and of the amount of computation saved by interpolation for the 89 stations used in this investigation. The stations are placed in the table in the order in which the computations were made. At stations Nos. 1, 31, 53, 8, 54, and 59 no interpolation was attempted.

Name of station	No. of station	Stations from which interpolation was made or attempted	Number of zones for which interpolation was accepted	Distance to nearest station from which interpolation was made or attempted	Inner radius of smallest zone for which the interpolation was accepted
				Kilometers	*Kilometers*
Key West, Fla.	1				
Calais, Me.	31				
Seattle, Wash. (university)	53				
Kansas City, Mo.	39	1 31 53	4	2020	5674
Madison, Wis.	37	31 53 39	11	625	642
Beaufort, N. C.	18	1 31 39	8	1245	1572
Cleveland, Ohio	33	18 31 37	7	665	2298
Boston, Mass.	29	18 33 31	7	445	2298
New York, N. Y.	27	29 18 33	13	298	340
Ithaca, N. Y.	32	29 33 27	13	280	340
Worcester, Mass.	28	29 27 32	15	62	245
Cambridge, Mass.	30	28 31 29	24	5	8
Baltimore, Md.	23	27 18 33	9	282	1194
Philadelphia, Pa.	24	27 23 32	17	140	188
Princeton, N. J.	25	24 27 32	19	62	99
Hoboken, N. J.	26	27 25 32	23	10	12
Atlanta, Ga.	15	18 1 39	7	718	2298
Charleston, S. C.	17	18 1 15	9	375	1194
Point Isabel, Tex.	8				
New Orleans, La.	5	15 8 1	5	685	3996
Apalachicola, Fla.	4	15 1 5	7	456	2298
West Palm Beach, Fla.	2	1 17 4	13	300	340
Punta Gorda, Fla.	3	2 1 4	15	202	245
Terre Haute, Ind.	35	33 39 15	*12	544	481
Cincinnati, Ohio	34	33 15 35	14	258	285
Charlottesville, Va.	19	18 34 23	8	217	1572
Deer Park, Md.	20	19 23 33	15	172	245
Washington, D. C. (Coast and Geodetic Survey Office)	21	23 19 20	17	60	188
Washington, D. C. (Smithsonian Institution)	22	21 19 20	27	1	2
McCormick, S. C.	16	15 17 19	15	192	245
Little Rock, Ark.	13	39 5 35	8	530	1572
Columbia, Tenn.	14	15 35 13	13	320	340
St. Louis, Mo.	38	35 14 39	14	262	285
Chicago, Ill.	36	35 33 37	15	210	245
McAlester, Okla.	12	39 8 13	10	318	873
San Francisco, Cal.	54				
Laredo, Tex.	9	8 54 13	7	280	2298
Austin, Tex. (university)	11	9 12 5	9	355	1194
Galveston, Tex.	7	11 8 5	13	303	340
Austin, Tex. (capitol)	10	11 8 7	24	1	8
Rayville, La.	6	5 7 13	13	260	340

* According to rule 1 the interpolation was accepted one zone too soon.

Name of station	No. of station	Stations from which interpolation was made or attempted	Number of zones for which interpolation was accepted	Distance to nearest station from which interpolation was made or attempted	Inner radius of smallest zone for which the interpolation was accepted
				Kilometers	*Kilometers*
Grand Canyon, Wyo.	50	53 54 37	6	980	2965
Gunnison, Colo.	45	50 54 9	7	747	2298
Wallace, Kans.	41	45 50 39	11	467	642
Ellsworth, Kans.	40	39 11 41	13	290	340
Denver, Colo.	44	41 50 45	10	210	873
Colorado Springs, Colo.	42	45 41 44	10	95	873
Pikes Peak, Colo.	43	42 45 44	13	18	340
Green River, Utah	47	45 54 50	7	283	2298
Salt Lake City, Utah	49	47 54 50	7	247	2298
Grand Junction, Colo.	46	45 50 47	15	138	245
Pleasant Valley Junction, Utah	48	46 47 49	13	120	340
Lower Geyser Basin, Wyo.	52	50 54 53	20	30	59
Norris Geyser Basin, Wyo.	51	50 52 53	19	17	99
Mt. Hamilton, Cal.	55	54 9 49	9	81	1194
Seattle, Wash. (high school)	56	53 54 51	24	3	8
Pembina, N. Dak.	59				
Iron River, Mich.	57	59 88 39	9	732	1194
Ely, Minn.	58	57 59 39	12	320	481
Mitchell, S. Dak.	60	39 44 59	7	590	2298
Sweetwater, Tex.	61	10 47 12	12	354	481
Kerrville, Tex.	62	9 61 10	15	138	244
El Paso, Tex.	63	9 55 41	6	840	2965
Compton, Cal.	66	55 9 49	6	497	2965
Yuma, Ariz.	65	66 63 47	6	353	2965
Nogales, Ariz.	64	65 63 47	7	382	2298
Goldfield, Nev.	67	55 65 49	7	390	2298
Yavapai, Ariz.	68	65 47 67	6	372	2965
Grand Canyon, Ariz.	69	68 67 47	16	3	213
Gallup, N. Mex.	70	63 47 65	10	407	873
Las Vegas, N. Mex.	71	63 41 70	6	310	2965
Shamrock, Tex.	72	61 40 71	12	307	481
Denison, Tex.	73	12 10 72	12	148	481
Minneapolis, Minn.	74	58 60 37	13	328	340
Lead, S. Dak.	75	60 50 44	12	468	481
Rock Springs, Wyo.	82	44 50 49	10	240	873
Sisson, Cal.	81	54 53 49	9	395	1194
Paxton, Nebr.	83	41 60 75	13	252	340
Hinsdale, Mont.	77	59 53 50	5	492	3996
Sandpoint, Idaho	78	77 53 52	8	440	1572
Bismarck, N. Dak.	76	60 77 59	12	363	481
Boise, Idaho	79	52 81 78	7	447	2298
Astoria, Oreg.	80	81 53 79	11	202	642
Washington, D. C. (Bureau of Standards)	84	21 20 23	24	8	8
North Hero, Vt.	85	32 * 29	13	331	340
Wilson, N. Y.	88	32 33 20	15	220	245
Potsdam, N. Y.	87	88 * 28	12	345	481
Lake Placid, N. Y.	86	87 85 27	15	82	245
Alpena, Mich.	89	88 57 36	11	420	642

* Fort Kent station. All of the results for this station were not available for this investigation.

CRITERIA OF ACCEPTED INTERPOLATIONS.

The computation for any station commenced with the small inner zones and proceeded outward. The two rules used by the computers in deciding at what zone it was allowable to begin to accept the interpolated values and to accept them for all larger zones were as follows:

Rule 1.—Commence to accept interpolated values as final with the first zone for which such interpolation is allowable under rule 2, provided it is beyond the zone containing the nearest of the three stations from which the interpolation is made.

Rule 2.—Let 0.0005 dyne be the interpolation limit for any zone. Subject to rule 1, acceptance of the interpolation may begin with a given zone if each of the three zones next within it shows an agreement between the interpolated and computed values which is within the interpolation limit.

Table of principal facts for 89 gravity stations in the United States.

Number and name of station	ϕ	λ	H	γ_0	Correction for elevation	Correction for topography and compensation	Computed gravity at station (g_c)	Observed gravity at station (g)	($g-g_c$)
	° ′	° ′	*Meters*						
1. Key West, Fla.	24 33.6	81 48.4	1	978.938	0.000	+0.032	978.970	978.969	−0.001
2. West Palm Beach, Fla.	26 42.8	80 02.8	2	979.089	− .001	+ .031	979.119	979.128	+ .009
3. Punta Gorda, Fla.	26 56.2	82 03	1	979.105	.000	+ .020	979.125	979.126	+ .001
4. Apalachicola, Fla.	29 43.5	84 58.8	4	979.316	− .001	+ .015	979.330	979.321	− .009
5. New Orleans, La.	29 57.0	90 04.2	2	979.333	− .001	+ .013	979.345	979.323	− .022
6. Rayville, La.	32 28	91 45	26	979.535	− .008	+ .008	979.535	979.542	+ .007
7. Galveston, Tex.	29 18.2	94 47.5	3	979.283	− .001	+ .007	979.289	979.271	− .018
8. Point Isabel, Tex.	26 04.7	97 12.4	8	979.044	− .002	+ .015	979.057	979.075	+ .018
9. Laredo, Tex.	27 30.5	99 31.2	129	979.147	− .040	+ .003	979.110	979.081	− .029
10. Austin, Tex. (capitol)	30 16.5	97 44.3	170	979.359	− .052	− .003	979.304	979.287	− .017
11. Austin, Tex. (university)	30 17.2	97 44.2	189	979.360	− .058	− .001	979.301	979.282	− .019
12. McAlester, Okla.	34 56.2	95 46.2	240	979.741	− .074	+ .001	979.668	979.632	− .036
13. Little Rock, Ark.	34 45.0	92 16.4	89	979.725	− .027	+ .001	979.699	979.720	+ .021
14. Columbia, Tenn.	35 36.7	87 02.5	207	979.799	− .064	+ .006	979.741	979.758	+ .017
15. Atlanta, Ga.	33 45.0	84 23.3	324	979.641	− .100	+ .014	979.555	979.523	− .032
16. McCormick, S. C.	33 54.8	82 18.0	163	979.655	− .050	+ .012	979.617	979.623	+ .006
17. Charleston, S. C.	32 47.2	79 56.0	6	979.561	− .002	+ .016	979.575	979.545	− .030
18. Beaufort, N. C.	34 43.1	76 30.8	1	979.722	.000	+ .036	979.758	979.728	− .030
19. Charlottesville, Va.	38 02.0	78 30.3	166	980.008	− .051	+ .002	979.959	979.937	− .022
20. Deer Park, Md.	39 25.0	79 19.8	770	980.130	− .238	+ .041	979.933	979.934	+ .001
21. Washington, D. C. (Coast and Geodetic Survey Office)	38 53.2	77 00.5	14	980.083	− .004	+ .004	980.083	980.111	+ .028
22. Washington, D. C. (Smithsonian Institution)	38 53.3	77 01.5	10	980.083	− .003	+ .003	980.083	980.113	+ .030
23. Baltimore, Md.	39 17.8	76 37.3	30	980.119	− .009	+ .006	980.116	980.096	− .020
24. Philadelphia, Pa.	39 57.1	75 11.7	16	980.178	− .005	+ .009	980.182	980.105	+ .013
25. Princeton, N. J.	40 21.0	74 39.5	64	980.212	− .020	+ .013	980.205	980.177	− .028
26. Hoboken, N. J.	40 44	74 02	11	980.248	− .003	+ .008	980.253	980.268	+ .015
27. New York, N. Y.	40 48.5	73 57.7	38	980.254	− .012	+ .011	980.253	980.266	+ .013
28. Worcester, Mass.	42 16.5	71 48.5	170	980.386	− .052	+ .018	980.352	980.323	− .029
29. Boston, Mass.	42 21.6	71 03.8	22	980.393	− .007	+ .013	980.399	980.395	− .004
30. Cambridge, Mass.	42 22.8	71 07.8	14	980.395	− .004	+ .010	980.401	980.397	− .004
31. Calais, Me.	45 11.2	67 16.9	38	980.649	− .012	+ .010	980.647	980.630	− .017
32. Ithaca, N. Y.	42 27.1	76 29.0	247	980.402	− .076	+ .005	980.331	980.299	− .032
33. Cleveland, Ohio	41 30.4	81 36.6	210	980.317	− .065	.000	980.252	980.240	− .012
34. Cincinnati, Ohio	39 08.3	84 25.3	245	980.105	− .076	+ .002	980.031	980.003	− .028
35. Terre Haute, Ind.	39 28.7	87 23.8	151	980.135	− .047	+ .001	980.089	980.071	− .018
36. Chicago, Ill.	41 47.4	87 36.1	182	980.342	− .056	+ .007	980.293	980.277	− .016
37. Madison, Wis.	43 04.6	89 24.0	270	980.458	− .083	+ .003	980.378	980.364	− .014
38. St. Louis, Mo.	38 38.0	90 12.2	154	980.061	− .048	+ .001	980.014	980.000	− .014
39. Kansas City, Mo.	39 05.8	94 35.4	278	980.101	− .086	− .001	980.014	979.989	− .025
40. Ellsworth, Kans.	38 43.7	98 13.5	469	980.069	− .145	− .004	979.920	979.925	+ .005
41. Wallace, Kans.	38 54.7	101 35.4	1,005	980.085	− .310	.000	979.775	979.754	− .021
42. Colorado Springs, Colo.	38 50.7	104 49.0	1,841	980.080	− .568	− .007	979.505	979.489	− .016
43. Pikes Peak, Colo.	38 50.3	105 02.0	4,293	980.079	−1.325	+ .187	978.941	978.953	+ .012
44. Denver, Colo.	39 40.6	104 56.9	1,638	980.153	− .505	− .015	979.633	979.608	− .025
45. Gunnison, Colo.	38 32.6	106 56.0	2,340	980.053	− .722	− .001	979.330	979.341	+ .011
46. Grand Junction, Colo.	39 04.2	108 33.9	1,398	980.099	− .431	− .051	979.617	979.632	+ .015
47. Green River, Utah	38 59.4	110 09.9	1,243	980.092	− .384	− .043	979.665	979.635	− .030
48. Pleasant Valley Junction, Utah	39 50.8	111 00.8	2,191	980.168	− .676	+ .024	979.516	979.511	− .005
49. Salt Lake City, Utah	40 46.1	111 53.8	1,322	980.250	− .408	− .041	979.801	979.802	+ .001
50. Grand Canyon, Wyo.	44 43.3	110 29.7	2,386	980.607	− .736	+ .038	979.909	979.898	− .011
51. Norris Geyser Basin, Wyo.	44 44.2	110 42.0	2,276	980.608	− .702	+ .031	979.937	979.949	+ .012
52. Lower Geyser Basin, Wyo.	44 33.4	110 48.1	2,200	980.592	− .679	+ .028	979.941	979.931	− .010
53. Seattle, Wash. (university)	47 39.6	122 18.3	58	980.872	− .018	− .020	980.834	980.732	− .102
54. San Francisco, Cal.	37 47.5	122 25.7	114	979.986	− .035	+ .045	979.996	979.964	− .032
55. Mount Hamilton, Cal.	37 20.4	121 38.6	1,282	979.947	− .396	+ .120	979.671	979.659	− .012
56. Seattle, Wash. (high school)	47 36.5	122 19.8	74	980.867	− .023	− .018	980.826	980.724	− .102
57. Iron River, Mich.	46 05.4	88 38.4	458	980.730	− .141	+ .014	980.603	980.632	+ .029
58. Ely, Minn.	47 48.6	92 01.0	448	980.886	− .138	+ .008	980.756	980.770	+ .014
59. Pembina, N. Dak.	48 58.1	97 14.9	243	980.990	− .075	− .009	980.906	980.916	+ .010
60. Mitchell, S. Dak.	43 41.8	98 01.8	408	980.514	− .126	− .006	980.382	980.374	− .008
61. Sweetwater, Tex.	32 28.4	100 24.1	655	979.535	− .202	+ .009	979.342	979.304	− .038
62. Kerrville, Tex.	30 01.3	99 07.6	498	979.339	− .154	+ .013	979.198	979.220	+ .022
63. El Paso, Tex.	31 46.3	106 29.0	1,146	979.478	− .354	+ .001	979.125	979.123	− .002
64. Nogales, Ariz.	31 21.3	110 56.6	1,181	979.445	− .364	+ .038	979.119	979.060	− .059
65. Yuma, Ariz.	32 43.3	114 37.0	54	979.555	− .017	− .010	979.528	979.528	.000
66. Compton, Cal.	33 53.4	118 13.2	20	979.652	− .006	.000	979.646	979.587	− .059
67. Goldfield, Nev.	37 42.2	117 14.5	1,716	979.979	− .529	+ .027	979.477	979.455	− .022
68. Yavapai, Ariz.	36 03.9	112 07.1	2,179	979.837	− .672	+ .034	979.199	979.191	− .008
69. Grand Canyon, Ariz.	36 05.3	112 06.8	849	979.839	− .262	− .096	979.481	979.462	− .019
70. Gallup, N. Mex.	35 31.8	108 44.2	1,990	979.791	− .614	+ .014	979.191	979.169	− .022
71. Las Vegas, N. Mex.	35 35.8	105 12.1	1,960	979.797	− .605	+ .017	979.209	979.203	− .006
72. Shamrock, Tex.	35 12.8	100 11.4	708	979.764	− .218	+ .007	979.553	979.576	+ .023
73. Denison, Tex.	33 45.3	96 32.8	230	979.641	− .071	− .001	979.569	979.565	− .004
74. Minneapolis, Minn.	44 58.7	93 13.9	256	980.630	− .079	− .005	980.546	980.596	+ .050
75. Lead, S. Dak.	44 21.1	103 45.6	1,590	980.573	− .491	+ .044	980.126	980.169	+ .043
76. Bismarck, N. Dak.	46 48.5	100 47.0	516	980.795	− .159	− .005	981.631	980.624	− .007
77. Hinsdale, Mont.	48 23.8	107 05.3	661	980.939	− .204	− .017	980.718	980.738	+ .020
78. Sandpoint, Idaho	48 16.4	116 33.3	637	980.927	− .197	− .044	980.686	980.679	− .007
79. Boise, Idaho	43 37.2	116 12.3	821	980.507	− .253	− .042	980.212	980.211	− .001
80. Astoria, Oreg.	46 11.3	123 50.2	1	980.740	.000	+ .008	980.748	980.726	− .022
81. Sisson, Cal.	41 18.3	122 19.6	1,048	980.298	− .323	+ .015	979.990	979.971	− .019
82. Rock Springs, Wyo.	41 35.1	109 13.2	1,910	980.324	− .589	− .001	979.734	979.738	+ .004
83. Paxton, Nebr.	41 07.4	101 21.3	932	980.282	− .288	+ .002	979.996	979.981	− .015
84. Washington, D.C. (Bureau of Standards)	38 56.3	77 04.0	103	980.086	− .032	+ .012	980.066	980.094	+ .028
85. North Hero, Vt.	44 49.1	73 17.5	35	980.615	− .011	− .009	980.595	980.587	− .008
86. Lake Placid, N. Y.	44 17.5	73 59.1	571	980.567	− .176	+ .032	980.423	980.420	− .003
87. Potsdam, N. Y.	44 40.1	74 58.8	130	980.602	− .040	− .004	980.558	980.570	+ .012
88. Wilson, N. Y.	43 18.4	78 49.6	87	980.478	− .027	− .002	980.449	980.430	− .019
89. Alpena, Mich.	45 03.8	83 27.0	178	980.638	− .055	.000	980.583	980.554	− .029

therefore show the merits of the new method of reduction in comparison with the Bouguer and the free-air methods.

The comparison of the new method is made with the Bouguer and free-air reductions, for the Bouguer postulates a total lack of compensation and a consequent high rigidity of the earth's crust while the free-air method assumes that each piece of topography is completely compensated for at zero depth. In his investigation, published in Appendix 1, Report for 1894, Mr. Putnam used what he called Faye's reduction, which is a modification of the free-air reduction, in that a correction is applied for the lack of compensation. This correction is added to or subtracted from the observed value and is equal to the vertical effect at the station of the attraction of an indefinitely extended horizontal plane of a thickness equal to the difference in elevation between the station and the surrounding country and of a density equal to the mean density of the surface of the earth. By this reduction, Mr. Putnam obtained anomalies which were, in general, much smaller than those obtained by either the Bouguer or free-air reduction. (See pp. 25–27, Appendix 1, Report for 1894.)

Number and name of station	Anomaly		
	New method ($g-g_c+0.007$)	Bouguer ($g_o''-\gamma_o$)	In free air ($g_o-\gamma_o$)
1. Key West, Fla.	+0.006	+0.031	+0.031
2. West Palm Beach, Fla.	+ .016	+ .040	+ .040
3. Punta Gorda, Fla.	+ .008	+ .021	+ .021
4. Apalachicola, Fla.	− .002	+ .006	+ .006
5. New Orleans, La.	− .015	− .009	− .009
6. Rayville, La.	+ .014	+ .012	+ .015
7. Galveston, Tex.	− .011	− .011	− .011
8. Point Isabel, Tex.	+ .025	+ .032	+ .033
9. Laredo, Tex.	− .022	− .039	− .026
10. Austin, Tex. (capitol)	− .010	− .038	− .020
11. Austin, Tex. (university)	− .012	− .040	− .020
12. McAlester, Okla.	− .029	− .062	− .035
13. Little Rock, Ark.	+ .028	+ .013	+ .022
14. Columbia, Tenn.	+ .024	.000	+ .023
15. Atlanta, Ga.	− .025	− .053	− .018
16. McCormick, S. C.	+ .013	.000	+ .018
17. Charleston, S. C.	− .023	− .014	− .014
18. Beaufort, N. C.	− .023	+ .006	+ .006
19. Charlottesville, Va.	− .015	− .038	− .020
20. Deer Park, Md.	+ .008	− .036	+ .042
21. Washington, D. C. (Coast and Geodetic Survey Office)	+ .035	+ .031	+ .032
22. Washington, D. C. (Smithsonian Institution)	+ .037	+ .032	+ .033
23. Baltimore, Md.	− .013	− .017	− .014
24. Philadelphia, Pa.	+ .020	+ .020	+ .022
25. Princeton, N. J.	− .021	− .021	− .015
26. Hoboken, N. J.	+ .022	+ .022	+ .023
27. New York, N. Y.	+ .020	+ .020	+ .024
28. Worcester, Mass.	− .022	− .031	− .011
29. Boston, Mass.	+ .003	+ .007	+ .009
30. Cambridge, Mass.	+ .003	+ .005	+ .006
31. Calais, Me.	− .010	− .011	− .007
32. Ithaca, N. Y.	− .025	− .050	− .027
33. Cleveland, Ohio	− .005	− .033	− .012
34. Cincinnati, Ohio	− .021	− .051	− .026
35. Terre Haute, Ind.	− .011	− .033	− .017
36. Chicago, Ill.	− .009	− .029	− .009
37. Madison, Wis.	− .007	− .041	− .011
38. St. Louis, Mo.	− .007	− .031	− .013
39. Kansas City, Mo.	− .018	− .055	− .026
40. Ellsworth, Kans.	+ .012	− .046	− .001
41. Wallace, Kans.	− .014	− .122	− .021
42. Colorado Springs, Colo.	− .009	− .205	− .023
43. Pikes Peak, Colo.	+ .019	− .221	+ .199
44. Denver, Colo.	− .018	− .199	− .040
45. Gunnison, Colo.	+ .018	− .246	+ .010
46. Grand Junction, Colo.	+0.022	−0.175	−0.036
47. Green River, Utah	− .023	− .197	− .073
48. Pleasant Valley Junction, Utah	+ .002	− .204	+ .019
49. Salt Lake City, Utah	+ .008	− .163	− .040
50. Grand Canyon, Wyo.	− .004	− .225	+ .027
51. Norris Geyser Basin, Wyo.	+ .019	− .194	+ .043
52. Lower Geyser Basin, Wyo.	− .003	− .210	+ .018
53. Seattle, Wash. (university)	− .095	− .128	− .122
54. San Francisco, Cal.	− .025	+ .002	− .013
55. Mount Hamilton, Cal.	− .005	− .014	+ .108
56. Seattle, Wash. (high school)	− .095	− .128	− .120
57. Iron River, Mich.	+ .036	− .008	+ .043
58. Ely, Minn.	+ .021	− .027	+ .022
59. Pembina, N. Dak.	+ .017	− .025	+ .001
60. Mitchell, S. Dak.	− .001	− .057	− .014
61. Sweetwater, Tex.	− .031	− .101	− .029
62. Kerrville, Tex.	+ .029	− .020	+ .035
63. El Paso, Tex.	+ .005	− .128	− .001
64. Nogales, Ariz.	− .052	− .149	− .021
65. Yuma, Ariz.	+ .007	− .016	− .010
66. Compton, Cal.	− .052	− .058	− .059
67. Goldfield, Nev.	− .015	− .183	+ .005
68. Yavapai, Ariz.	− .001	− .179	+ .026
69. Grand Canyon, Ariz.	− .012	− .190	− .115
70. Gallup, N. Mex.	− .015	− .228	− .008
71. Las Vegas, N. Mex.	+ .001	− .206	+ .011
72. Shamrock, Tex.	+ .030	− .048	+ .030
73. Denison, Tex.	+ .003	− .029	− .005
74. Minneapolis, Minn.	+ .057	+ .017	+ .045
75. Lead, S. Dak.	+ .050	− .089	+ .087
76. Bismarck, N. Dak.	.000	− .069	− .012
77. Hinsdale, Mont.	+ .027	− .070	+ .003
78. Sandpoint, Idaho	.000	− .122	− .051
79. Boise, Idaho	+ .006	− .134	− .043
80. Astoria, Oreg.	− .015	− .014	− .014
81. Sisson, Cal.	− .012	− .120	− .004
82. Rock Springs, Wyo.	+ .011	− .208	+ .003
83. Paxton, Nebr.	− .008	− .116	− .013
84. Washington, D. C. (Bureau of Standards)	+ .035	+ .029	+ .040
85. North Hero, Vt.	− .001	− .021	− .017
86. Lake Placid, N. Y.	+ .004	− .034	+ .029
87. Potsdam, N. Y.	+ .019	− .006	+ .008
88. Wilson, N. Y.	− .012	− .031	− .021
89. Alpena, Mich.	− .022	− .049	− .029

For all of the 89 stations considered as a single group the means are as follows:

	Anomaly		
	New method	Bouguer	In free air
Mean with regard to sign	− 0.002	− 0.065	− 0.001
Mean without regard to sign	.018	.073	.028
Mean with regard to sign *	.000	− .064	+ .002
Mean without regard to sign *	.017	.072	.026

* The last two lines of table show the means with the two Seattle stations omitted.

For the 89 stations the mean anomaly without regard to sign for the new method of reduction is about six-tenths as large as for the free-air method of reduction, and is about one-fourth as large as for the Bouguer method.

At 60 stations out of 89 the new-method anomaly is less than the free-air anomaly, and at 3 other stations the two are equal. At 68 stations out of 89 the new-method anomaly is less than the Bouguer anomaly, and at 5 other stations the anomalies of the two methods are equal.

The maximum anomaly by the new method is −0.095 (stations 53 and 56, both at Seattle, Wash.), by the free-air method is +0.199 (station 43, Pikes Peak), and by the Bouguer method −0.246 (station 45, Gunnison, Colo.).

The comparisons and the table on which they are based show clearly that the new method of reduction is a much closer approximation to the truth than either of the older methods.

POSSIBLE RELATIONS OF ANOMALIES TO TOPOGRAPHY.

It is important to know whether the anomalies as determined by the new method of reduction show any relation to the topography. Therefore, in the following tables the 89 stations have been arranged in groups with reference to their relation to the topography.

Sixteen coast stations, in the order of their distance from the 1000-fathom line.

Name and number of station	Distance from 1000-fathom line	Anomaly		
		New method $(g-g_0+0.007)$	Bouguer $(g_0''-\gamma_0)$	In free air $(g_0-\gamma_0)$
	Kilometers			
54. San Francisco, Cal.	85	−0.025	+0.002	−0.013
18. Beaufort, N. C.	95	− .023	+ .006	+ .006
80. Astoria, Oreg.	120	− .015	− .014	− .014
1. Key West, Fla.	150	+ .006	+ .031	+ .031
8. Point Isabel, Tex.	160	+ .025	+ .032	+ .033
5. New Orleans, La.	210	− .015	− .009	− .009
4. Apalachicola, Fla	225	− .002	+ .006	+ .006
27. New York, N. Y.	225	+ .020	+ .020	+ .024
68. Compton, Cal.	230	− .052	− .058	− .059
26. Hoboken, N. J.	230	+ .022	+ .022	+ .023
2. West Palm Beach, Fla.	243	+ .016	+ .040	+ .040
3. Punta Gorda Fla.	280	+0.008	+0.021	+0.021
7. Galveston, Tex.	330	− .011	− .011	− .011
29. Boston, Mass	300	+ .003	+ .007	+ .009
30. Cambridge, Mass.	300	+ .003	+ .005	+ .006
17. Charleston, S. C.	305	− .023	− .014	− .014
Mean with regard to sign		− .004	+ .005	+ .005
Mean without regard to sign		.017	.019	.020

Eighteen stations near the coast, in the order of their distances from the open coast.

Number and name of station	Distance from open coast	Anomaly		
		New method $(g-g_0+0.007)$	Bouguer $(g_0''-\gamma_0)$	In free air $(g_0-\gamma_0)$
	Kilometers			
31. Calais, Me.	50	−0.010	−0.011	−0.007
25. Princeton, N. J.	60	− .021	− .021	− .015
23. Baltimore, Md	75	− .013	− .017	− .014
28. Worcester, Mass.	85	− .022	− .031	− .011
24. Philadelphia, Pa.	90	+ .020	+ .020	+ .022
81. Sisson, Cal.	142	− .012	− .120	− .004
21. Washington, D. C. (Coast and Geodetic Survey Office)	170	+ .035	+ .031	+ .032
22. Washington, D. C. (Smithsonian Institution)	170	+ .037	+ .032	+ .033
84. Washington, D. C. (Bureau of Standards)	175	+ .035	+ .029	+ .040
9. Laredo, Tex.	215	−0.022	−0.039	−0.026
65. Yuma, Ariz.	220	+ .007	− .016	− .010
16. McCormick, S. C.	235	+ .013	.000	+ .018
10. Austin, Tex. (capitol)	245	− .010	− .038	− .020
11. Austin, Tex. (university)	245	− .012	− .040	− .020
19. Charlottesville, Va.	250	− .015	− .038	− .020
32. Ithaca, N. Y.	305	− .025	− .050	− .027
62. Kerrville, Tex.	310	+ .029	− .020	+ .035
6. Rayville, La.	325	+ .014	+ .012	+ .015
Mean with regard to sign		+ .002	− .018	+ .001
Mean without regard to sign		.020	.031	.020

Twenty-seven stations in the interior of the continent and not in mountainous regions, arranged in the order of elevation.

Number and name of station	Elevation	Anomaly		
		New method ($g-g_c+0.007$)	Bouguer ($g_0''-\gamma_0$)	In free air ($g_0-\gamma_0$)
	Meters			
88. Wilson, N. Y.	87	−0.012	−0.031	−0.021
13. Little Rock, Ark.	89	+ .028	+ .013	+ .022
87. Potsdam, N. Y.	130	+ .019	− .006	+ .008
35. Terre Haute, Ind.	151	− .011	− .033	− .017
38. St. Louis, Mo.	154	− .007	− .031	− .013
89. Alpena, Mich.	178	− .022	− .049	− .029
36. Chicago, Ill.	182	− .009	− .029	− .009
14. Columbia, Tenn.	207	+ .024	.000	+ .023
33. Cleveland, Ohio	210	− .005	− .033	− .012
73. Denison, Tex.	230	+ .003	− .029	− .005
12. McAlester, Okla.	240	− .029	− .062	− .035
59. Pembina, N. Dak.	243	+ .017	− .025	+ .001
34. Cincinnati, Ohio	245	− .021	− .051	− .026
74. Minneapolis, Minn.	256	+ .057	+ .017	+ .045
37. Madison, Wis.	270	− .007	− .041	− .011
39. Kansas City, Mo.	278	− .018	− .055	− .026
	Meters			
15. Atlanta, Ga.	324	−0.025	−0.053	−0.018
60. Mitchell, S. Dak.	408	− .001	− .057	− .014
58. Ely, Minn.	448	+ .021	− .027	+ .022
57. Iron River, Minn.	458	+ .036	− .008	+ .043
40. Ellsworth. Kans.	469	+ .012	− .046	− .001
76. Bismarck, N. Dak.	516	.000	− .069	− .012
61. Sweetwater, Tex.	655	− .031	− .101	− .029
77. Hinsdale, Mont.	661	+ .027	− .070	+ .003
72. Shamrock, Tex.	708	+ .030	− .048	+ .030
83. Paxton, Nebr.	932	− .008	− .116	− .013
41. Wallace, Kans.	1005	− .014	− .122	− .021
Mean with regard to sign		+ .002	− .043	− .004
Mean without regard to sign		.018	.045	.019

Sixteen stations in mountainous regions and below the general level, arranged in the order of their distances below the general level.

Number and name of station	Average elevation within 100 miles of station minus elevation of station	Elevation of station	Anomaly		
			New method ($g-g_c+0.007$)	Bouguer ($g_0''-\gamma_0$)	In free air ($g_0-\gamma_0$)
	Meters	*Meters*			
70. Gallup, N. Mex.	30	1990	−0.015	−0.228	−0.008
67. Goldfield, Nev.	112	1716	− .015	− .183	+ .005
85. North Hero, Vt.	167	35	− .001	− .021	− .017
63. El Paso, Tex.	205	1146	+ .005	− .128	− .001
45. Gunnison, Colo.	380	2340	+ .018	− .246	+ .010
82. Rock Springs, Wyo.	379	1910	+ .011	− .208	+ .003
42. Colorado Springs, Colo.	420	1841	− .009	− .205	− .023
49. Salt Lake City, Utah	570	1322	+ .008	− .163	− .040
44. Denver, Colo.	574	1638	− .018	− .199	− .040
79. Boise, Idaho	575	821	+ .006	− .134	− .043
78. Sandpoint, Idaho	588	637	.000	− .122	− .051
69. Grand Canyon, Ariz.	824	849	− .012	− .190	− .115
46. Grand Junction, Colo.	850	1398	+ .022	− .175	− .036
	Meters	*Meters*			
47. Green River, Utah	870	1243	−0.023	−0.197	−0.073
56. Seattle, Wash. (high school)	456 .	74	− .095	− .128	− .120
53. Seattle, Wash. (university)	472	58	− .095	− .128	− .122
Mean with regard to sign			− .013	− .166	− .042
Mean without regard to sign			.022	.166	.044
After rejecting the two Seattle stations, No. 56 and No. 53:					
Mean with regard to sign			− .002	− .171	− .031
Mean without regard to sign			.012	.171	.033

Twelve stations in mountainous regions and above the general level, arranged in the order of their distance above the general level.

Number and name of station	Elevation of station minus average elevation within 100 miles	Elevation of station	Anomaly		
			New method ($g-g_c+0.007$)	Bouguer ($g_0''-\gamma_0$)	In free air ($g_0-\gamma_0$)
	Meters	*Meters*			
71. Las Vegas, N. Mex.	18	1960	+0.001	−0.206	+0.011
52. Lower Geyser Basin, Wyo.	63	2200	− .003	− .210	+ .018
51. Norris Geyser Basin, Wyo.	139	2276	+ .019	− .194	+ .043
48. Pleasant Valley Junction, Utah	147	2191	+ .002	− .204	+ .019
50. Grand Canyon, Wyo.	249	2386	− .004	− .225	+ .027
64. Nogales, Ariz.	288	1181	− .052	− .149	− .021
20. Deer Park, Md.	291	770	+ .008	− .036	+ .042
86. Lake Placid, N. Y.	306	571	+ .004	− .034	+ .029
	Meters	*Meters*			
75. Lead, S. Dak.	468	1590	+0.050	−0.089	+0.087
68. Yavapai, Ariz.	512	2179	− .001	− .179	+ .026
55. Mount Hamilton, Cal.	1202	1282	− .005	− .014	+ .108
43. Pikes Peak, Colo.	2035	4293	+ .019	− .221	+ .199
Mean with regard to sign			+ .003	− .147	+ .049
Mean without regard to sign			.014	.147	.052

Note that for the ocean stations, Nos. 1 to 7, there is in each case but one change of sign as successive zones are considered, namely, the change of sign due to distance. The water compartments predominate in their effects in every zone.

At station No. 1, over a deep part of the ocean where the bottom is nearly level to a great distance from the station, the positive corrections beyond the change of sign due to distance have nearly the same aggregate as the negative corrections before the change of sign, and, therefore, the total correction for topography and compensation is small. At stations Nos. 2 and 3, near the Tonga Deep, this balance of positive and negative corrections is slightly disturbed in one sense—the positive correction predominates; and at stations Nos. 4 and 5, over the Tonga Deep, the balance is greatly disturbed in the opposite sense, the negative corrections being largely in excess. These are probably typical cases.

Note that stations Nos. 6 to 9 constitute a progressive series of four in relation to topography. No. 6 is over deep water near an oceanic island, No. 7 over water of moderate depth nearer to the oceanic island, No. 8 near sea level on the coast of a high oceanic island, and No. 9 on a high summit of such an island. Note that the corrections for topography and compensation stand in order, namely, +0.019, +0.078, +0.162, and +0.469. A comparison of values for corresponding zones in the preceding table for these four stations will indicate the manner in which the positive corrections gradually gain predominance as the station is made to approach from deep water to the summit of an oceanic island. While making this comparison it will be well to consult pages 65–71 in regard to the change of sign due to distance. .

Stations Nos. 11 and 12 are like station No. 8 in being near sea level on the shore of an oceanic island surrounded by deep water. Note the resemblance between these three stations as to the correction for separate zones. In each case the sum of the corrections out to zone L is small, but beyond that large positive corrections appear and the total correction for each station is positive and large, corresponding to the known fact that large values of gravity are ordinarily observed in such a location.

Station No. 13 is remarkable for having unusually small corrections in every zone—all positive.

Station No. 14 shows a succession of values characteristic of stations on a high plateau far from any ocean. The large positive corrections for near zones are more than offset by still larger and more numerous negative corrections beyond the change of sign due to distance, which occurs at zone J, and the total correction is, therefore, large and negative. The very large negative values in zones K to O are due to the fact that the high plateau extends far enough from the station to fill these zones. The negative corrections are numerous because, the station being far from the nearest ocean, the water effects do not predominate and positive corrections do not appear again until a very large zone is reached, namely, No. 6, of which the inner radius is 2900 kilometers.

A comparison in detail of the corrections for separate zones at stations Nos. 15 and 16 will show why the corrections for topography and compensation tend to be large and positive for a station above the general level in a mountainous country and negative for a station far below the general level in the same region. Note that the positive corrections for small zones are much smaller at station No. 16 at the bottom of one of the deep valleys than at station No. 15 on a high summit of the Alps, and that the change of sign due to distance occurs before zone G at No. 16 and after zone J at No. 15. These two differences between the two stations are due largely to the effect of corrections due to the differences of elevation of the station and the zone ("station below compartment" and "station above compartment") shown in the reduction tables on pages 30–43. Consult especially the reduction table for zone G on page 35 in connection with the correction for zone G at these two stations. It will also be noted that for the same reason the negative corrections, beyond the change of sign due to distance and before the water effects begin to predominate, are larger for corresponding zones at station No. 16 as a rule. This is especially noticeable for zones K, L, M, and N.

EFFECTS OF TOPOGRAPHY AND COMPENSATION—WHY COMBINED.

In the investigation of the figure of the earth and isostasy by means of observed deflections of the vertical, the whole effect of the topography was first computed and later the effect of the isostatic compensation was combined with it.* In the present investigation, based on gravity determinations, the effects of topography and of compensation have been combined as early as was feasible in the processes of deriving formulæ and of computing. Thus, as indicated on pages 23 and 24, instead of computing the two effects separately for distant zones they were combined in formula (20) and the resultant effect computed at once and tabulated in the reduction tables on pages 44–47. So, too, for near zones the principal part of the reduction tables (pp. 30–43) refers to resultant effects, not to separate effects. The only columns in these tables showing separate effects are columns 2 and 3, and these were not used in the regular computations.

Why was this departure made from the methods of the earlier investigation?

This departure was decided upon immediately after a preliminary reconnoissance of the problem. It then appeared probable that, for all zones except for those very near the station, the two opposing effects of topography and compensation would be nearly equal, and their difference, therefore, much smaller than either one. Under these circumstances it appeared that to compute each of the opposing effects with sufficient accuracy to secure the required degree of accuracy in their difference it would be necessary to secure several significant figures in the computation. If this supposition were true, it would be necessary in making the separate computations, either to make the compartments of the separate zones very small and numerous, and hence the computation very slow, or, otherwise, if large compartments were used, it would be necessary to make the estimate of mean elevation in each compartment with such a high degree of accuracy as to be both slow and difficult. On the other hand, it appeared that in the direct computation of the resultant difference of effects, it would be necessary to use but two or three significant figures in the computation, that the compartments could be made large and therefore not very numerous, and that only an approximate estimate of the mean elevation in each compartment would be required and could, therefore, be made quickly and easily. It seemed, therefore, that so much would be gained in rapidity and ease of computation by the proposed departure from the earlier practice that these gains should outweigh all other considerations.

Now, this investigation being complete, the writers have an opportunity to review the decision in the light of accumulated facts and greater experience. In that light it appears that the decision was wise for zones which are more than 26° from the station—zones 6 to 1 of the present investigation. For these zones the difference of the effect of the topography and the effect of the compensation is less than one-tenth of either; that is, E_R is less than one-tenth of either E_T or E_C (p. 25). For nearer zones the difference, as a rule, is a much greater proportional part. Hence, for these nearer zones the gain in rapidity and ease made by dealing directly with the difference of effects rather than with the separate effects was not great, and therefore the decision was not wise. Moreover, it appears now that if the separate effects had been computed for these nearer zones it would have given the investigator a clearer and more precise insight into the problems involved. It would also have facilitated studies of the relation of the computed results to the assumption as to the depth of compensation and possibly to some other assumptions.

If, therefore, an entire new investigation were being made the writers believe it would be wise to compute the two effects separately for zones A to O and 18 to 7, but the gain to be secured does not seem to be sufficiently great to warrant the revision of the present investigation and the remodeling of the reduction tables here printed.

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* The Figure of the Earth and Isostasy from Measurements in the United States, pp. 68-73.

Number and name of station	Effect of topography and compensation	Effect of compensation within outer limit of—						Anomaly, new method [1] ($g-g_c$ +0.007) (local compensation)	Anomaly with regional compensation within outer limit of—		
		Zone K		Zone M		Zone O					
		Local	Regional	Local	Regional	Local	Regional		Zone K	Zone M	Zone O
Stations in United States											
42. Colorado Springs, Colo.	−0.007	−0.036	−0.036	−0.094	−0.093	−0.165	−0.164	−0.009	−0.009	−0.010	−0.010
43. Pikes Peak, Colo.	+ .187	− .052	− .044	− .113	− .100	− .189	− .172	+ .019	+ .011	+ .006	+ .002
44. Denver, Colo.	− .015	− .026	− .028	− .076	− .085	− .152	− .169	− .018	− .016	− .009	− .001
45. Gunnison, Colo.	− .001	− .041	− .044	− .120	− .128	− .212	− .210	+ .018	+ .021	+ .026	+ .016
46. Grand Junction, Colo.	− .051	− .026	− .028	− .082	− .089	− .156	− .170	+ .022	+ .024	+ .029	+ .036
48. Pleasant Valley Junction, Utah	+ .024	− .040	− .041	− .103	− .100	− .171	− .159	+ .002	+ .003	− .001	− .010
49. Salt Lake City, Utah	− .041	− .026	− .028	− .075	− .078	− .137	− .143	+ .008	+ .010	+ .011	+ .014
54. San Francisco, Cal.	+ .045	.000	.000	− .002	− .003	+ .009	+ .033	− .025	− .025	− .024	− .049
55. Mt. Hamilton, Cal.	+ .120	− .012	− .012	− .017	− .009	− .018	− .003	− .005	− .005	− .013	− .020
57. Iron River, Mich.	+ .014	− .007	− .008	− .020	− .020	− .031	− .024	+ .036	+ .037	+ .036	+ .029
58. Ely, Minn.	+ .008	− .006	− .008	− .018	− .021	− .031	− .029	+ .021	+ .023	+ .024	+ .019
59. Pembina, N. Dak.	− .009	− .004	− .004	− .011	− .012	− .023	− .025	+ .017	+ .017	+ .018	+ .019
60. Mitchell, S. Dak.	− .006	− .006	− .007	− .016	− .019	− .033	− .037	− .001	.000	+ .002	+ .003
61. Sweetwater, Tex.	+ .009	− .011	− .012	− .028	− .029	− .049	− .049	− .031	− .030	− .030	− .031
62. Kerrville, Tex.	+ .013	− .009	− .010	− .024	− .025	− .038	− .032	+ .029	+ .030	+ .030	+ .023
63. El Paso, Tex.	+ .001	− .020	− .021	− .054	− .055	− .098	− .104	+ .005	+ .006	+ .006	+ .011
64. Nogales, Ariz.	+ .038	− .020	− .020	− .046	− .041	− .076	− .069	− .052	− .052	− .057	− .059
65. Yuma, Ariz.	− .010	− .001	− .001	− .004	− .006	− .012	− .018	+ .007	+ .007	+ .009	+ .013
66. Compton, Cal.	.000	.000	− .001	− .002	− .004	− .011	− .024	− .052	− .051	− .050	− .039
67. Goldfield, Nev.	+ .027	− .030	− .030	− .077	− .078	− .137	− .141	− .015	− .015	− .014	− .011
68. Yavapai, Ariz.	+ .034	− .030	− .030	− .080	− .080	− .137	− .129	− .001	− .001	− .001	− .009
69. Grand Canyon, Ariz.	− .096	− .028	− .029	− .079	− .080	− .136	− .127	− .012	− .011	− .011	− .021
70. Gallup, N. Mex.	+ .014	− .036	− .036	− .095	− .095	− .163	− .156	− .015	− .015	− .015	− .022
71. Las Vegas, N. Mex.	+ .017	− .036	− .035	− .094	− .094	− .160	− .150	+ .001	.000	+ .001	− .009
72. Shamrock, Tex.	+ .007	− .013	− .012	− .031	− .031	− .055	− .056	+ .030	+ .029	+ .030	+ .031
73. Denison, Tex.	− .001	− .004	− .004	− 010	− .009	− .018	− .017	+ .003	+ .003	+ .002	+ .002
74. Minneapolis, Minn.	− .005	− .004	− .005	− .012	− .013	− .022	− .024	+ .057	+ .058	+ .058	+ .059
75. Lead, S. Dak.	+ .044	− .026	− .027	− .064	− .061	− .102	− .089	+ .050	+ .051	+ .047	+ .037
76. Bismarck, N. Dak.	− .005	− .008	− .009	− .024	− .026	− .044	− .047	.000	+ .001	+ .002	+ .003
77. Hinsdale, Mont.	− .017	− .010	− .012	− .030	− .034	− .058	− .067	+ .027	+ .029	+ .031	+ .036
78. Sandpoint, Idaho	− .044	− .014	− .014	− .045	− .049	− .086	− .095	.000	.000	+ .004	+ .009
79. Boise, Idaho	− .042	− .016	− .018	− .047	− .051	− .094	− .108	+ .006	+ .008	+ .010	+ .020
80. Astoria, Oreg.	+ .008	.000	.000	− .002	− .005	.000	+ .008	− .015	− .015	− .012	− .023
81. Sisson, Cal.	+ .015	− .022	− .026	− .058	− .059	− .096	− .088	− .012	− .008	− .011	− .020
82. Rock Springs, Wyo.	− .001	− .036	− .034	− .093	− .093	− .169	− .177	+ .011	+ .009	+ .011	+ .019
83. Paxton, Nebr.	+ .002	− .014	− .016	− .041	− .043	− .073	− .077	− .008	− .006	− .006	− .004
85. North Hero, Vt.	− .009	.000	− .001	− .003	− .007	− .012	− .016	− .001	.000	+ .003	+ .003
86. Lake Placid, N. Y.	+ .032	− .011	− .012	− .024	− .021	− .033	− .020	+ .004	+ .005	+ .001	− .009
87. Potsdam, N. Y.	− .004	− .002	− .003	− .008	− .010	− .017	− .017	+ .019	+ .020	+ .021	+ .019
88. Wilson, N. Y	− .002	.000	− .002	− .003	− .004	− .011	− .017	− .012	− .010	− .011	− .006
89. Alpena, Mich.	.000	− .004	− .003	− .010	− .008	− .016	− .016	− .022	− .023	− .024	− .022
Mean with regard to sign								+ .002	+ .003	+ .003	+ .001
Mean without regard to sign								.017	.017	.017	.019
Stations not in United States											
15. Gornergrat, Switzerland	+ .165	− .049	− .047	− .099	− 081	− .140	− .093	[2]+ .049	+ .047	+ .031	+ .002
16. St. Maurice, Switzerland	− .091	− .021	− .024	− .064	− .069	− .103	− .085	+ .003	+ .006	+ .008	− .014
8. Honolulu, Hawaiian Islands	+ .162	− .001	− .001	+ .011	+ 019	+ 072	+ .137	+ .052	+ .052	+ .044	− .013
9. Mauna Kea, Hawaiian Islands	+ .469	− .049	− .036	− .070	− .036	− 020	+ .108	+ .183	+ .170	+ .149	+ .055
Mean with regard to sign								+ .072	+ .069	+ .058	+ .007
Mean without regard to sign								.072	.069	.058	.021

[1] See p. 74.

[2] See p. 81.

The mean, without regard to sign, of the anomalies by the new method for the 41 stations in the United States shown in the above table is 0.017 dyne. For the regional compensation the means, without regard to sign, for the anomalies of the same stations are 0.017 dyne, 0.017 dyne, and 0.019 dyne, respectively, for the three cases of areas limited by zones K, M, and O. The mean anomaly, without regard to sign, for these 41 stations in the United States is practically the same for the two methods of distribution of compensation. The mean, without regard to sign, for the regional compensation only, with zones K and M limiting the area, is the same as for the local compensation—that is, 0.017 dyne—while the mean, without regard to sign, for the regional compensation is 0.019 dyne for zone O.

The means, without regard to sign, of the anomalies for the six stations, Nos. 54, 62, 65, 66, 80, 81, on or near the coast, are as follows: Local compensation, 0.023 dyne; regional compensation to zones K, M, and O, 0.023, 0.023, and 0.028 dyne, respectively.

The means, without regard to sign, of the anomalies for the 14 stations, Nos. 57, 58, 59, 60, 61, 72, 73, 74, 76, 77, 83, 87, 88, 89, which are in the interior of the United States and not in mountainous regions, are: Local compensation, 0.020 dyne; regional compensation to zones K, M, and O, 0.020, 0.021, and 0.020 dyne, respectively.

The means, without regard to sign, of the anomalies for the 21 stations, Nos. 42, 43, 44, 45, 46, 48, 49, 55, 63, 64, 67, 68, 69, 70, 71, 75, 78, 79, 82, 85, 86, in the above table, which are in the mountainous regions, are: Local compensation, 0.013 dyne; regional compensation to zones K, M, and O, 0.013, 0.014, and 0.017 dyne, respectively.

The means for the stations in the interior not in mountainous regions show that there are no differences of importance in the four mean anomalies. This is what one would expect with no prominent topographic features near a station, the effect of the compensation being practically the same whether the compensation is local or distributed uniformly over an area of greater extent.

The results for the stations at or near the coast and those in mountainous regions show that the mean, without regard to sign, is practically the same for the method of local distribution and for regional distribution with zones K and M limiting the area considered. The mean anomaly for the method of regional distribution, with zone O limiting the area in the case of stations on or near the coast, is 22 per cent larger than the anomaly of the method of local compensation. The mean anomaly for the mountain stations in the case of regional distribution to zone O is 31 per cent greater than the anomaly for the local compensation.

If the separate anomalies in the United States be compared, it is found that in 16 cases out of 41 the anomaly with local compensation assumed is smaller than with regional compensation assumed uniformly distributed to zone K (18.8 kilometers), and only 13 cases in which it is larger. Similarly, there are 20 cases out of 41 in which the anomaly with local compensation is smaller than with regional compensation extending to zone M (58.8 kilometers), and only 15 cases in which it is larger. There are 26 cases out of 41 in which the anomaly with local compensation assumed is smaller than with regional compensation assumed to extend to zone O (166.7 kilometers), and only 12 cases in which it is larger. In all other cases the two anomalies compared are identical to the last decimal place used, the third.

The evidence either for or against local compensation in comparison with such regional compensation distributed uniformly over these moderate distances is necessarily slight and possibly inconclusive. For, as shown in the table, the difference between computed effects of compensation in the two cases compared is very small upon an average. The whole evidence is furnished by these very small differences, which are frequently less than the errors of observation and computation. As shown by the table, there is but one station among the 41—namely, No. 43, Pikes Peak—at which the difference between the computed effect of local compensation and the computed effect of regional compensation uniformly distributed to zone K exceeds 0.004. Such a difference tends to become greater as the distance over which the regional compensation is supposed to be uniformly distributed is increased, but columns 7 and 8 of the table show that even when the regional compensation is assumed to extend to zone O, a distance of 166.7 kilometers from the station, there is only one station among the 41—namely, station No. 54, San Francisco—at which the difference between the computed effect of local compensation and the computed effect of regional compensation exceeds 0.017 dyne.

Nevertheless the evidence, slight as it necessarily is, indicates that the assumption of local compensation is nearer the truth than the assumption of regional compensation uniformly distributed to zone K (18.8 kilometers). The evidence is still stronger in the same direction when the comparison is made between local compensation and regional compensation extending uniformly to the greater distances, 58.8 and 166.7 kilometers, represented by zones M and O.

It is possible that the assumption of regional compensation only, extending uniformly to some distance from the station less than 18.8 kilometers, may be nearer the truth than the

compensation alone for each lettered zone had already been computed for certain stations, including the 11 used in the present test. Hence, for these zones the required change, as shown below, was obtained at once by multiplying the effect of compensation for a given zone by the percentage shown in the preceding table for that zone. For each numbered zone at a station the total correction for that zone, as shown in the tables on pages 54–58 and 84, was multiplied by the percentage of reduction in E_R for the zone, as shown in the above table, the total correction for the zone being sensibly proportional to E_R.

Changes in computed correction for topography and compensation produced by changing the assumed depth of compensation from 113.7 to 85.3 kilometers.

[All tabular values are in units of the fourth decimal place in dynes.]

Zone	Pembina, No. 59	Grand Canyon, No. 69	Pikes Peak, No. 43	San Francisco, No. 54	Mauna Kea, Hawaiian Islands	Gallup, No. 70	Grand Junction, No. 46	Mount Hamilton, No. 55	Salt Lake City, No. 49	Lake Placid, No. 86	Iron River, No. 57
A	0	0	0	0	0	0	0	0	0	0	0
B	0	0	− 2	0	− 1	0	0	0	0	0	0
C	0	0	− 2	0	− 3	− 1	− 1	0	− 1	0	0
D	0	− 2	− 5	0	− 6	− 2	− 2	−2	− 2	0	0
E	0	− 3	− 8	0	− 8	− 5	− 3	−3	− 3	− 1	0
F	0	− 3	−12	0	−13	− 7	− 3	−3	− 3	− 2	0
G	0	− 5	−13	0	−16	− 8	− 5	−4	− 5	− 4	0
H	0	− 8	−18	0	−18	−10	− 7	−5	− 7	− 2	0
I	0	−15	−28	0	−30	−19	−13	−6	−13	− 6	− 6
J	−5	−18	−28	0	−23	−23	−15	−6	−17	− 7	− 5
K	−5	−29	−38	0	−30	−32	−26	−8	−25	−11	−10
L	−5	−34	−42	− 2	−26	−39	−36	−4	−32	−12	−10
M	−7	−50	−60	− 3	−15	−58	−56	−3	−49	−10	−12
N	0	0	− 1	0	0	− 1	− 1	0	− 1	0	0
O	+7	+29	+40	−11	−37	+35	+38	0	+33	+ 5	+ 6
18	+2	+10	+12	− 4	−12	+11	+13	0	+11	+ 2	+ 1
17	+2	+10	+12	− 4	−14	+11	+14	0	+12	+ 2	+ 1
16	+2	+ 9	+13	− 4	−16	+12	+14	0	+12	+ 2	+ 1
15	+3	+10	+13	− 4	−17	+14	+14	0	+14	+ 2	+ 1
14	+3	+11	+13	− 4	−18	+14	+14	−2	+14	+ 2	+ 2
13	+6	+19	+19	− 6	−36	+21	+23	−5	+25	+ 3	+ 4
12	+3	+13	+12	− 6	−24	+11	+13	−5	+15	+ 1	+ 3
11	+3	+ 6	+ 7	− 5	−20	+ 8	+ 8	−5	+ 9	− 1	+ 2
10	+3	+ 1	+ 4	− 3	−15	+ 2	+ 4	−4	+ 3	− 3	+ 2
9	+2	− 1	0	− 2	− 9	− 1	− 1	−2	− 1	− 2	0
8	+1	− 3	− 2	− 4	−10	− 3	− 3	−4	− 3	− 3	0
7	−1	− 2	− 2	− 2	− 5	− 2	− 2	−2	− 2	− 2	− 1
6	−2	− 2	− 2	− 2	− 5	− 2	− 2	−2	− 2	− 2	− 2
5	−3	− 2	− 2	− 2	− 2	− 2	− 2	−2	− 2	− 2	− 2
4	−2	− 2	− 2	− 2	− 1	− 2	− 2	−2	− 2	− 2	− 1
3	−1	− 2	− 1	− 1	− 1	− 1	− 1	−1	− 1	− 1	− 1
2	−1	− 1	− 1	− 1	− 1	− 1	− 1	−1	− 1	− 1	− 1
1	0	0	0	0	0	0	0	0	0	0	0
Total.	+5	−64	−124	−72	−432	−80	−27	−81	−24	−55	−28

The total change shown for each station at the bottom of the above table is repeated to three decimal places in the third column of the following table. The values in the second column were obtained from the table on page 74. The values in the fourth column were obtained by combining those in the second and third columns. The values in the fifth column were obtained from the table on page 76. The values in the last column were obtained by combining those in the third and fifth columns.

areas surrounded by contours marked −0.200 occur in the highest part of the Rocky Mountain region. No such relation of anomalies to topography shows on illustration No. 16.

Third, the anomalies shown on illustration No. 17 are much larger than those shown in illustration No. 16; about four times as large on an average.

These three contrasts are strong evidence that the assumptions involved in the new method of reduction are much nearer the truth than those involved in the Bouguer method.

The free-air anomalies are shown on illustration No. 18. The mean anomaly was used for each of the following pairs or groups of close stations in constructing the contours: Nos. 21, 22, and 84; Nos. 26 and 27; Nos. 29 and 30, and Nos. 50, 51, and 52. The contours were smoothed out slightly in southern Texas in the vicinity of stations Nos. 9, 10, 11, and 62.

The anomalies for stations Nos. 43, 55, and 69 were not used in constructing the contours on illustration No. 18. No. 43 is on the summit of Pikes Peak, much higher than the two adjacent stations, Nos. 42 at Colorado Springs and No. 44 at Denver, which were used in constructing the contours. No. 55 is on Mount Hamilton, much higher than No. 54 at San Francisco on which the contours in this vicinity are based. Station No. 69 is at the bottom of the Grand Canyon of the Colorado, far below the general level of this region. The contours near this locality are based on station No. 68 on the rim of the canyon. The difference between the anomalies of the high and low stations of each of these pairs is great and in each case the station which has been rejected in drawing the contours is far above or far below the genearl level of the region and has a very large anomaly. This is the characteristic of the free-air reduction and is a strong indication that this method is far from the truth in mountainous country.

This rejection of stations Nos. 43, 55, and 69 in constructing contour lines on illustration No. 18 has made these contours show much more favorably for the free-air method of reduction than they otherwise would do, for in each case the contours have been based upon the station of the pair which has the smaller anomaly. Even with this discrimination in favor of illustration No. 18 it still compares unfavorably with illustration No. 16, as indicated in the following paragraph:

A close comparison between illustration No. 18 and No. 16 shows that in general the same areas of excess and of defect show on both, but as a rule the maximum anomaly in each area is greater on illustration No. 18 than on illustration No. 16, as indicated in the two tables which follow:

Negative areas, gravity in defect.

States in which the maximum anomalies occur	Maximum New Method anomaly, illustration 16		Maximum Free-air anomaly, illustration 18	
	Station	Amount	Station	Amount
New York	32	−0.025	32	−0.027
South Carolina	17	− .023	17	*− .014
Georgia	15	− .025	15	*− .018
Ohio	34	− .021	34	− .026
Michigan	89	− .022	89	− .029
Oklahoma	12	− .029	12	− .035
Texas	9	− .022	9	− .026
Texas	61	− .031	61	*− .029
Colorado	44	− .018	44	− .040
Utah	47	− .023	47	− .073
Arizona	64	− .052	64	*− .021
California	66	− .052	66	− .059
California	54	− .025	54	*− .013
Washington	53	− .095	53	− .122
Mean		− .033		− .038

* These 5 are the only cases out of 14 in which the maximum in a given area is less on illustration No. 18 than on illustration No. 16.

formation. These exceptionally large negative anomalies confirm the general conclusion drawn from the table that stations on recent geologic formations tend to have large negative anomalies.

Of the 20 gravity stations which stand on Cenozoic formations, 9, nearly one-half of them, have positive anomalies, but the remaining 11 negative anomalies are sufficiently large to make the mean of the 20 equal to −0.011, as shown in the table.

Among the 19 stations on Paleozoic formation, No. 74 at Minneapolis, Minn., has the largest anomaly, namely, +0.057 dyne. This station is near the edge of a great Paleozoic area in a point extending from the main body of that area into a pre-Cambrian area. The large positive anomaly found at this station is the prevailing characteristic of stations in pre-Cambrian areas.

The evidence of correlation between the prevailing signs of new method anomalies and the geologic formations on which the stations stand which has here been set forth is weak in certain respects. It deals with present surface geology only, as seen in large areas on a small scale geologic map. A thorough study of the evidence should deal with past as well as present surface geology, should deal with the subsurface geology taking into account as far as possible the thickness of the strata of various formations, and possibly also the details of the geology in the immediate vicinity of the station should be considered.

Nevertheless, it is believed that further evidence will support the generalization now made for the United States that at stations in pre-Cambrian areas gravity tends to be in excess and at stations in Cenozoic areas tends to be in defect. The first case corresponds to excess of mass or undercompensation of topography for all land stations, and the second case to defect of mass or overcompensation of topography for all land stations.

In general pre-Cambrian formations are of greater density than Cenozoic formations. Hence, the correlation noted is of the character to be expected if one considers that surface densities, that is the density of masses near the station, have more influence over gravity at the station than the density of masses lying deeper and, therefore, farther from the station. This slightly predominating effect of surface densities is very clearly shown in the first line of the table on page 109, the mass being considered limited to a horizontal distance of 1280 meters from the station. On the other hand, in the last line of the same table in which the masses considered are assumed to extend to a great distance (1190 kilometers) horizontally from the station, the predominance of surface effects is much less pronounced. In the latter case the attracting mass is, to the first approximation, a flat plate of indefinite extent. The attraction of such a plate upon a point outside it in the direction perpendicular to the plane of the plate is independent of the distance of the point from the plate. It matters comparatively little, therefore, in the case represented by the last line of the table whether the attracting mass is distributed through a large depth or is concentrated near the surface. Even in this case, however, variations of density near the surface have greater proportionate effects than variations of density which may occur deep beneath the surface.

Measured in terms of strata of normal density on the hypothesis used on page 111 the excess of mass in pre-Cambrian areas corresponds on an average to a stratum somewhat more than 600 feet thick and the defect of mass in the Cenozoic areas to a stratum somewhat less than 400 feet thick. The considerations stated on pages 109–111 indicate that this excess or defect of mass is probably distributed through a depth at least as great as 15 000 feet.

When one attempts to study the possible correlation of new method anomalies and geologic formations simply by comparing illustrations Nos. 16 and 19 (in the pocket at the end of the volume) with the geologic map of North America which was used, two apparently significant coincidences are noted.

First, three comparatively small detached areas of pre-Cambrian formation are shown in the United States on the geologic map, each far from any other outcrop of the same formation, one at the Black Hills near the boundary between South Dakota and Wyoming, one in Texas west of Austin, and one in Missouri about 50 miles to the southwestward of Chester, Ill.*

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* On the map this area is so small that it is difficult to be certain about the geological symbol with which it is marked. The writers have, however, been assured by a geologist that this is a pre-Cambrian area and that the authors of this map must have intended to have it so marked.

possible extent of the small area of excessive density near Fernandina which is indicated by deflections of the vertical.

The Adirondacks.—The deflections of the vertical proved with considerable certainty that an area of excessive density coincides approximately with the mountains, and the limits of the area seemed to be fairly well defined. The gravity stations Nos. 85, 86, and 87, in this immediate vicinity, together with stations Nos. 28, 32, and 88, at a moderate distance, serve to show the distribution of gravity in this region more definitely than for most parts of the United States. As indicated on illustration No. 16, the gravity observations agree with the deflection observations in showing that northern New York is a region of excessive density. The gravity observations differ from the deflection observations simply in indicating that the region of excess does not extend so far to the southward and does extend farther to the westward and the northward than it had been drawn on illustration No. 19, based upon deflections alone. This is not a direct conflict of evidence, for a reexamination of the residuals of deflection observations, as shown by the arrows on illustration No. 19, reveals that they are not inconsistent with the supposition that the area of excess has the shape and size indicated on illustration No. 16. Illustration No. 16 indicates that the positive anomaly in the Adirondacks is less than 0.010 dyne, corresponding to the stratum in excess only 330 feet thick. The mean elevation in the Adirondacks is much more than 330 feet. On the other hand, the anomaly +0.019 at Potsdam (No. 87) corresponds to a stratum in excess 630 feet thick, whereas the elevations in this region are much less than 630 feet.

Coast of Maine, New Hampshire, and Massachusetts.—There are no gravity stations within the area along the coast of New England shown on illustration No. 19 as an area of excessive density on the evidence of deflections of the vertical. Stations Nos. 28–31, all near this area, have anomalies which do not contradict the evidence given by the deflections of the vertical.

Rock Springs, Tex.—From deflection observations the conclusion had been reached that an area of excessive density exists in Texas, having its center in latitude 30° and longitude 100°, as shown on illustration No. 19. Gravity station No. 62, Kerrville, located within the indicated limits of this area has an anomaly of +0.029 dyne and thus decisively confirms the evidence given by the deflections. In connection with the discussion of the deflections attention was called to the fact that the only area of pre-Cambrian rocks shown in Texas on a certain geologic map of North America lies about 100 kilometers to the northeastward of the center of this area of excessive density, as shown on illustration No. 19. Gravity station No. 62 lies still nearer this lone area of pre-Cambrian rocks. The region of excessive density around station No. 62 limited by the zero contour, as drawn on illustration No. 16 on the basis of the evidence from gravity observations alone, extends far enough north to overlap the pre-Cambrian area. This suggests that possibly there is a real connection between the geological history of this region and the arrangement of densities put in evidence by the deflections and gravity observations. (See p. 115.) On the basis of 0.003 dyne being equivalent to 100 feet of strata the anomaly +0.029 at station No. 62 is equivalent to a stratum in excess 970 feet thick. On the other hand, if this anomaly be due to excesses of density confined to the first 15 000 feet of depth, as is suggested by the relation to surface geology commented upon, and if this area of excess extends for somewhat more than 166.7 kilometers around the station, then the table on page 109 indicates that each 100 feet of excess stratum would correspond to more than 0.0034 in the anomaly and that therefore the anomaly of +0.029 would correspond to a stratum of about 800 feet added to the first 15 000 feet. This would produce an increase in density of about 8 parts in 150, or from 2.67 to 2.81. This is within the range of possibility.

Sherman, Tex.—A possible area of excessive density in the vicinity of Sherman, Tex., with its center in latitude 33¾° and longitude 96½°, of which the existence was considered to be doubtful when the evidence of deflections alone was available, has a gravity station, No. 73, near its center for which the anomaly is +0.003 dyne. This anomaly is so small that it can hardly be considered sufficient proof of the existence of this area of excessive density; but the evidence, though slight, is in harmony with that furnished by deflections of the vertical. The contours on illustration No. 16 show this region of excessive density as merely a connection

is below and positive if the station is above the general level. This is also true of the corrections for topography and compensation. Among the 14 stations in mountainous regions below the general level, after excluding the 2 Seattle stations (p. 78), the mean correction for topography and compensation is +0.003 dyne for the first 7 stations, all less than 500 meters below the general level, and is −0.047 for the remaining 7, all more than 500 meters below the general level. Similarly in the group of 12 stations in mountainous regions and above the general level (p. 78) the mean correction for topography and compensation is +0.028 for the first 5 stations, all less than 250 meters above the general level and +0.071 for the remaining 7 stations, all more than 250 meters above. (Compare these means with the corresponding means of the free-air anomalies given on p. 80.)

The relations to which attention is called in the preceding paragraphs may be seen also in part by comparing illustrations Nos. 18 and 16 (in the pocket at the end of the volume). As the corrections for topography and compensation are small, less than 0.020 dyne, at three-fourths of all the stations these two illustrations have a general resemblance to each other. East of the one hundredth meridian the resemblance is rather close. West of the one hundredth meridian, where the country is mountainous and a large proportion of the stations lie far below or far above the general level of the surrounding country, there is much less resemblance. It is very significant that even the general resemblance west of the one hundredth meridian would largely disappear if illustration No. 18 were drawn using all stations in that area, for the lines of equal anomaly on that illustration would then become very irregular and close together. In drawing these lines of equal anomaly on illustration No. 18, stations Nos. 43, 55, and 69, each lying either far above or far below the general level of the country, were rejected.

The evidence seems to be strong that at any station where the correction for topography and compensation is large this neglected correction forms a large part of the free-air anomaly for that station.

On the whole, it appears that the observed relations between Bouguer anomalies and topography, and between free-air anomalies and topography, are what one would predict on the supposition that the new method of computation is a very close approximation to the truth. Therefore, these observed relations are in themselves evidence of the validity of the new method of computation. As these particular observed relations of Bouguer and free-air anomalies to topography are known to be world-wide, having long been known and frequently commented upon in connection with gravity observations in other countries than the United States, this line of evidence in favor of the new method of computation is world-wide and correspondingly strong.

COMMENT ON THE FAYE METHOD OF REDUCTION.

The new method of reduction has been compared with the Bouguer and free-air methods of reduction, since these are the two methods which have been used as a rule during the past few years in the reports of the International Geodetic Association and elsewhere. The Bouguer method postulates a total lack of compensation and a consequent high rigidity of the earth's crust. The free-air method assumes that each piece of topography is completely compensated for at zero depth. In his investigation, published in Appendix I, Coast and Geodetic Survey Report for 1894,* Assistant G. R. Putnam also used Faye's method of reduction, which is a modification of the free-air method in that a correction is applied for lack of compensation. This correction is equal to the vertical effect at the station of the positive or negative attraction of an indefinitely extended horizontal plane of a thickness equal to the difference in elevation between the station and the surrounding country and of a density equal to the mean surface density of the earth. By this reduction Mr. Putnam obtained anomalies which were in general much smaller than those obtained by him in using either the Bouguer or the free-air reduction. After calling attention to this fact, Mr. Putnam, in the publication referred to, states that "it is probable that no particular significance attaches to these residuals remaining after the

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* See especially pp. 24–27 and 29.